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Sky at Night

#162 NOVEMBER 2018

The return of ORION

WINTER'S MOST BEAUTIFUL CONSTELLATION IS BACK

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CELEBRATING 10 YEARS

INSIGHT INVESTMENT ASTRONOMY PHOTOGRAPHER OF THE YEAR

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This month's contributors include...

Paul Abel
Visual observer

Paul is the inaugural writer of our new Field of View column, a forum for amateur astronomers to air their views. *Page 25*

Sandra Kropa
Space writer

Sandra had to consider some big issues while reviewing the Astronomer Royal's new book *On The Future* for us. *Page 102*

Mary McIntyre
Astrophotographer

In a double-whammy of articles Mary reveals both how to take great star trail photos and how to process them too. *Pages 82 and 84*

Iain Todd
Staff writer

Eye On The Sky host Iain has also curated all our great-looking 10th anniversary IIAPY coverage for this issue. *Page 6*

Welcome

Prize-winning astrophotography takes centre stage this issue

As images of the night sky go, they don't get any better than those you'll find on page 40 this month, where we present the winners of the 2018 Insight Investment Astronomy Photographer of the Year competition. This year marks the contest's 10th anniversary and there's a special retrospective of a decade of award-winning astro images on page 6.

There's an undeniable beauty in all the targets pictured and our mini mag, free with this month's issue, will help you to take great photos. Starting off with smartphones we show you how to take your first steps in snapping the night sky, moving onto taking better quality images with a DSLR camera, before introducing the specialist kit and techniques that will take your astrophotography further. Turn to the centre of the magazine to find it.

This month is a great time to start your journey – there's so much to see! The constellation of Orion provides an anchor in the winter skies thanks to its recognisable shape. Yet within its borders are also some stunning deep-sky sights for those with larger apertures. Turn to page 62 to begin Pete Lawrence's telescope tour of these, taking in the Orion Nebula and treasures beyond.

And we've got a visual excursion of the many delights elsewhere in the night sky on page 36. You'll find 30 great sights to observe this month ranging from planetary nebulae to highlights of the cratered lunar landscape, all put together with beginners in mind.

Enjoy the issue!

Chris Bramley Editor

PS Our next issue goes on sale 15 November.

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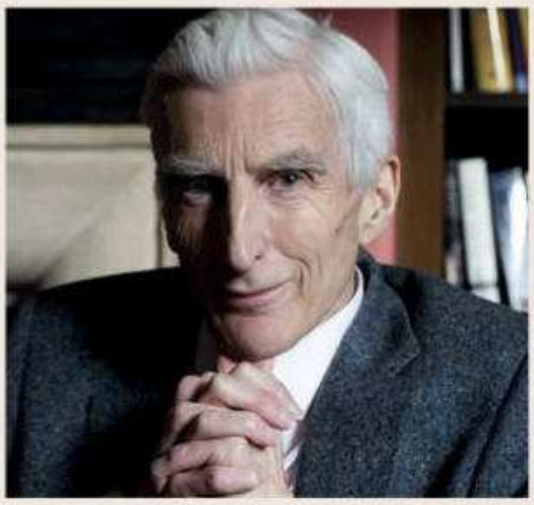
HOW TO FIND IT

Visit **www.skyatnightmagazine.com/bonuscontent**, select November's Bonus Content from the list and enter the authorisation code **M9DL8S8** when prompted

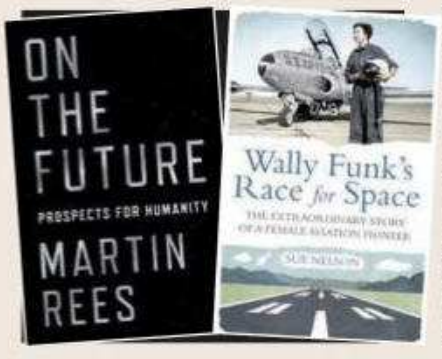
THERE'S MORE ONLINE

November highlights



INTERVIEW: The future of humanity

This month we are in conversation with the Astronomer Royal, Martin Rees. The distinguished astrophysicist discusses the challenges facing our planet, the prospects for space exploration and the search for extra-terrestrial intelligence.



Excerpts from the latest astro books

Read about a pioneer from the 1960s 'Women in Space' programme and the future of artificial intelligence.

The Sky at Night: Expedition Asteroid

The team looks at the new space missions attempting to collect asteroid samples and return them to Earth for study.

IIAPY: the winning astrophotos revealed

View the 31 top images from the Insight Investment Astronomy Photographer of the Year 2018 competition.

And much more...

- ▷ **Hotshots gallery**
- ▷ **Eye on the sky**
- ▷ **Extra EQMOD files**
- ▷ **Binocular tour**
- ▷ **Equipment review guide**
- ▷ **Desktop wallpaper**
- ▷ **Observing forms**
- ▷ **Deep-sky tour chart**

EVERY MONTH

Virtual Planetarium

With Paul Abel and Pete Lawrence

Discover November's night-sky highlights with Paul and Pete

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abc Audit Bureau of Circulations
20,693 (combined; Jan-Dec 2017)

ISSN 1745-9869

COVER MAIN IMAGE: JOHANNES SCHEDLER/CCDGUIDE.COM, THIS PAGE: WILL GATER, NASA/JPL-CALTECH/MSSS, NICOLAS LEFAUDEUX, WWW.SECRETSTUDIO.NET, BBC, ROLF WAHL OLSEN

10 YEAR ANNIVERSARY

Insight Investment

Astronomy Photographer of the Year

The winners

2018 is the 10th anniversary of the Insight Investment Astronomy Photographer of the Year competition. Here, we present the stunning images that have clinched the top spot over the decade since it began. To see this year's winner, turn to page 40

2009 – Category: Deep Space

▼ Horsehead Nebula (IC 434)

Martin Pugh (UK), Dudley, 16 March 2009

Equipment: SBIG STL11000 CCD camera, RC Optical Systems 12.5-inch Ritchey-Chrétien, Software Bisque Paramount ME mount

2010 – Category:
Earth and Space

▲ Blazing Bristlecone

Tom Lowe (US), Ancient Bristlecone Pine Forest, California, US, August 2009

Equipment: Canon EOS 5D Mark II DSLR camera, Canon EF 16-35mm lens

2011 – Category:
Our Solar System

▶ Jupiter with Io and Ganymede

Damian Peach (UK), Marley Vale, Saint Philip, Barbados, 12 September 2010

Equipment: Point Grey Flea3 mono CCD camera, Celestron EdgeHD 14 Schmidt-Cassegrain

10 YEAR ANNIVERSARY

2012 – Category: Deep Space

◀ M51: The Whirlpool Galaxy

Martin Pugh (UK), Sierra Nevada, US, 19 June 2012

Equipment: Apogee U16M CCD camera, PlaneWave 17-inch CDK astrograph, Software Bisque Paramount ME mount

2013 – Category: Earth and Space

▼ Guiding Light to the Stars

Mark Gee (Australia), Wairarapa, New Zealand, 8 June 2013

Equipment: Canon EOS 5D Mark III DSLR camera, 24mm f/2.8 lens

2014
Category:
Earth and
Space

◀ Aurora over a Glacier Lagoon

James Woodend (UK), Jökulsárlón, Vatnajökull National Park, Iceland, 9 January 2014

Equipment: Canon EOS 5D Mk III DSLR camera, 33mm f/3.2 lens

10 YEAR ANNIVERSARY

2015 – Category: Skyscapes

▲ Eclipse Totality over Sassendalen

Luc Jamet (France), Spitsbergen, Svalbard, Norway, 20 March 2015

Equipment: Canon EOS 7D DSLR camera, 16mm f/5 lens

2017 – Category: Stars and Nebulae

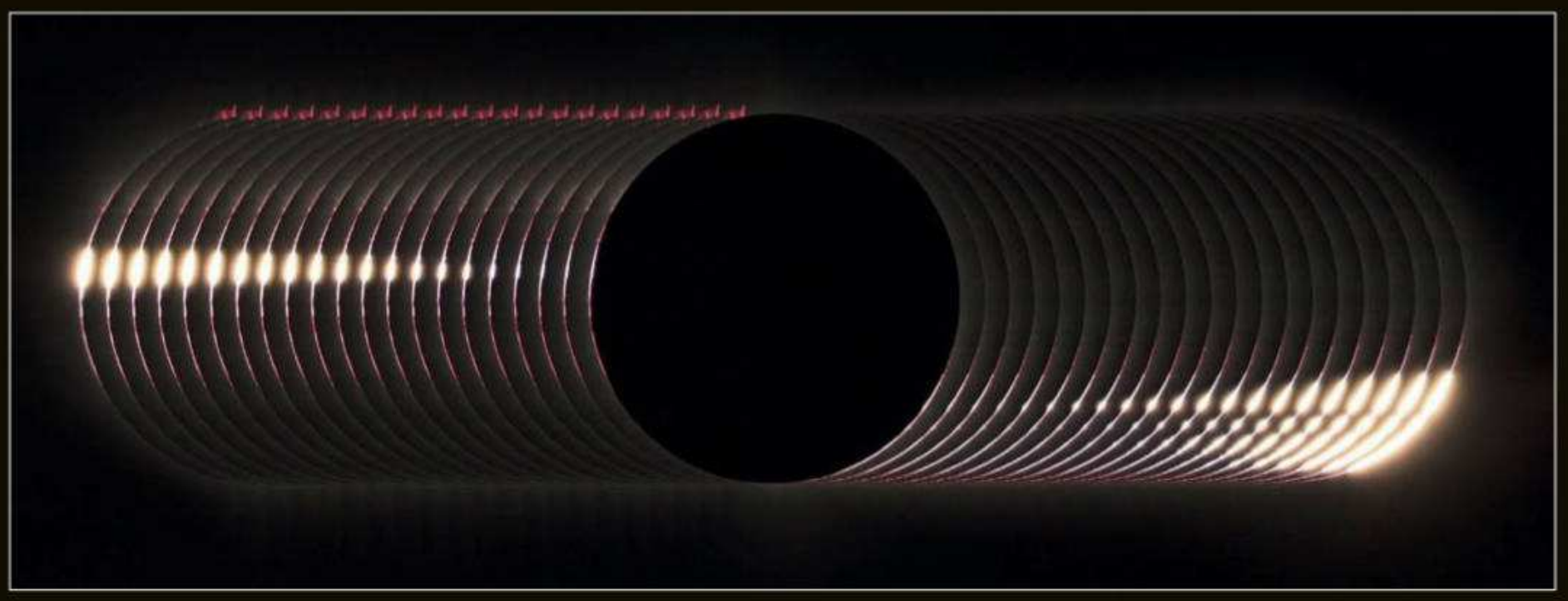
▶ The Rho Ophiuchi Clouds

Artem Mironov (Russia), Hakos Guest Farm, Windhoek, Namibia, 6 August 2016

Equipment: Canon EOS 5D Mark II DSLR camera, Sky-Watcher 200P reflector, Sky-Watcher HEQ5 Pro SynScan mount

YOUR BONUS CONTENT

A gallery of stunning space images



2016 – Category: Our Sun

▲ Baily's Beads

Yu Jun (China), Luwuk, Central Sulawesi, Indonesia

Equipment: Canon EOS 5D Mark II DSLR camera, Sigma DG OS HSM 150-600mm lens

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NGC7635 image by Gordon Haynes www.imagingtheheavens.co.uk

The Widescreen Centre

Autumn & Winter 2018

The winter skies are returning. Time to plan ahead for the winter's observing and astrophotography! With the end of summertime, and sunset and the Pleiades rising around 4.30pm at the beginning of the month, there;s lots to see. Orion clears the horizon around 10pm. The Widescreen Centre is a real showroom you can visit and see the latest priduwhich cts and get expert advice before you buy.
Your hobby is important. You want to be sure you're getting the best. Check in with us for events around the country or here at our dark-sky site in Cambridgeshire
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Bulletin

The latest astronomy and space news written by **Elizabeth Pearson**

PLUS CUTTING EDGE

Our experts examine the hottest new astronomy research papers

Part of the Large Magellanic Cloud (centre) rotates in a different direction to the rest of it, which may be evidence it swallowed a smaller galaxy

ISTOCK

MAGELLANIC CLOUDS could have been a trio

Did the Large Magellanic Cloud engulf a third galaxy billions of years ago?

The Large and Small Magellanic Clouds are a familiar sight in the southern sky, but the pair could once have been a trio. A newly published study has found signs that the Large Magellanic Cloud (LMC) engulfed another small galaxy around three to five billion years ago.

Most of the stars in the Large Magellanic Cloud rotate clockwise around its centre. However, a small population rotates anti-clockwise. It was initially thought these stars may have originated in the Small Magellanic Cloud, but Benjamin Armstrong from the University of Western Australia considered another option.

"Our idea was that these stars might have come from a merger with another galaxy in the past," says Armstrong. He used computer models to simulate what would happen during a galactic collision like this. "What we found is that in this sort of merging event, you actually get quite a strong counter rotation after a merger takes place."

The finding could help explain the distribution of stellar ages within the cloud's star clusters. Usually, the stars in a cluster all have a similar age. "In the Large Magellanic Cloud, we have very old clusters as well as ones that are very young – but nothing in between. This is known as the age gap problem," says Armstrong.

Mergers are known to kick-start new formation. If the cloud had stopped forming new stars before a merger created a new flush of stellar growth there would appear to be separate populations of stars with a significant age gap between them.

▸ **See Comment, right**

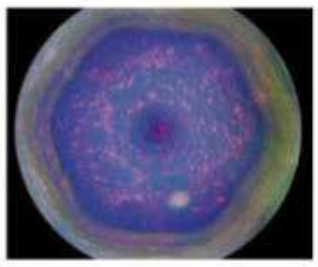
COMMENT by Chris Lintott

This revelation about the LMC might help solve a long-standing cosmological mystery, as predicting the number of satellite galaxies that surround galaxies like the Milky Way is something of a challenge. These small systems are believed mostly to have formed early, and so how many there are is very sensitive to details of the make up of the Universe, especially to what we assume about the amount of dark matter and how it behaves.

Most astronomers believe that, although it is mysterious, there is much more dark than ordinary matter, but for years models with plenty of dark matter have predicted more satellite galaxies than we see. More sensitive surveys have found fainter systems, but this new result may suggest they've had more complex lives than we would otherwise expect. If mergers of satellites are common, we need to do more than just count them – we need to understand their histories too.

CHRIS LINTOTT co-presents *The Sky at Night*

NEWS IN BRIEF



HIGH WINDS ON SATURN

Newly analysed infrared observations of Saturn's northern pole taken by NASA's Cassini spacecraft have revealed a previously unseen vortex that reaches hundreds of kilometres into the planet's stratosphere.

"The edges of this newly found vortex appear to be hexagonal, precisely matching a famous and bizarre hexagonal cloud pattern we see deeper down in Saturn's atmosphere," says Leigh Fletcher of the University of Leicester, who led the study.

SPACE JUNK DEORBITED

In September UK company RemoveDEBRIS successfully tested a net that will one day be used to dispose of space junk. In future these nets will capture the debris, after which an attached CubeSat will drag it into Earth's atmosphere where it will burn up. Space junk is an increasing concern for space operators, as uncontrolled debris can collide with important satellites, destroying them. RemoveDEBRIS will also test a harpoon designed to capture larger pieces of unwanted orbital scrap.

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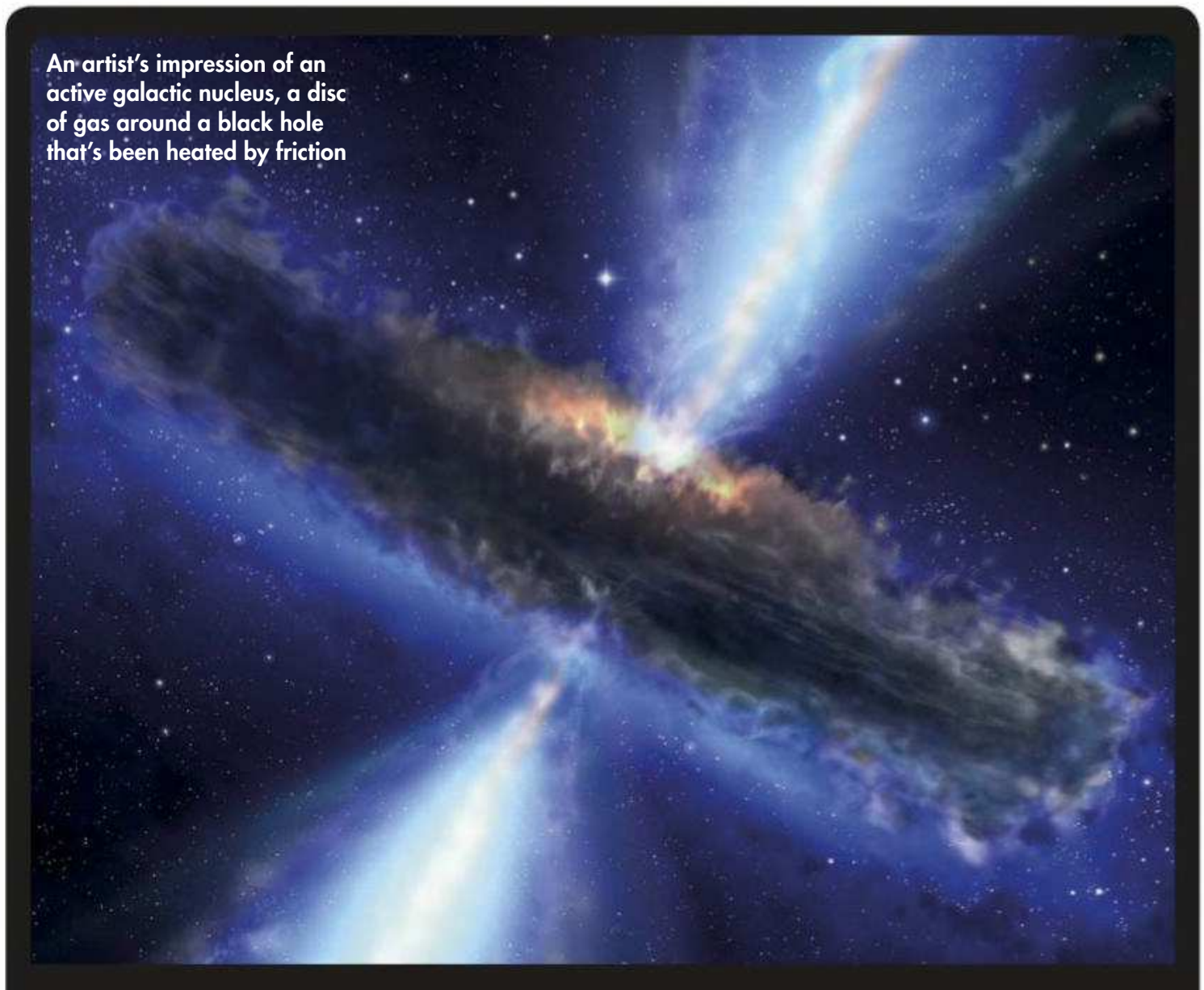


An artist's impression of an active galactic nucleus, a disc of gas around a black hole that's been heated by friction

Matter plunges into black hole at a THIRD THE SPEED OF LIGHT

Gas fell directly into the singularity rather than circling it more slowly

A black hole has been caught feasting at a colossal rate, with gas falling into it at around 33 per cent the speed of light. A new study observed gas around the supermassive black hole at the centre of PG1211+143, a galaxy about a billion lightyears away in the direction of Coma Berenices.

The supermassive black hole is, like many others of its kind, surrounded by a disc of gas. As gas is drawn by gravity towards the black hole, friction causes the disc to heat up and glow, creating an extremely bright region known as an active galactic nucleus.

University of Leicester professor of astronomy Ken Pounds, who led the team that made the discovery, said, "The galaxy we were observing with XMM-Newton [the X-ray space telescope] has a 40 million solar mass black hole, which is very bright and evidently well fed. Indeed some 15 years ago we detected a powerful wind indicating the hole was being over-fed."

Usually the rotation of the disc causes gas to spiral into the black hole, slowing its acceleration. However, the light from PG1211+143 is extremely redshifted suggesting that it's travelling at enormous speeds.

"We were able to follow an Earth-sized clump of matter for about a day as it was pulled towards the black hole, accelerating to a third of the velocity of light before… plunging directly into the hole itself," says Pounds.

The gas had almost no rotation around the black hole, allowing it to approach extremely close to its event horizon and reach speeds of around 100,000 km/s; the speed of light is approximately 300,000 km/s.

It's thought this strange behaviour is caused by a misalignment between the black hole's rotation and the plane of its disc. It's commonly assumed these two line up, but there is no reason to believe that this is always the case.

Pounds' observations back up recent theoretical work which suggests that misaligned accretion discs create rings of gas that can collide with each other. When they do, clumps of gas are torn off and swallowed directly by the black hole.

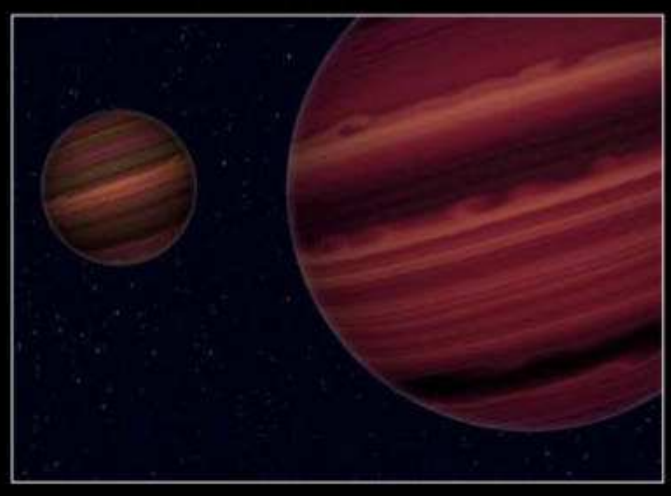
sci.esa.int/xmm-newton

Stars vs brown dwarves

A new study suggests that brown dwarves could be larger than previously thought possible. The research will help scientists pin down the line separating stars from brown dwarves.

Brown dwarves and stars begin their lives the same way. If they have enough mass they will fuse hydrogen atoms together, producing heat and light. Below a certain mass fusion doesn't happen and they instead become brown dwarves.

The mass needed to trigger fusion is not known exactly, but current theories predict it lies between 70 to 73 times the mass of Jupiter. However, a team of researchers has now found a brown dwarf that is 75 Jupiter masses in size.



▲ The difference between a star and a brown dwarf may not be as massive as previously thought

"We showed that the heaviest brown dwarves and the lightest stars may only have slight differences in mass. But despite this, they are destined for different lives – one racing to dim and cool, the other shining for billions of years," says Serge Dieterich from the Carnegie Institute for Science, who led the study.

carnegiescience.edu

Japan probes land on asteroid

Now the rovers will literally hop across the asteroid's surface

The first rovers to land on an asteroid's surface were dropped onto the space rock 162173 Ryugu on 21 September. A pair of rovers were deployed as part of the Hayabusa2 mission that has been at Ryugu since June. At the time of writing, a third rover was due to be sent down to the asteroid on 30 October.

The Japanese space agency plans on taking samples of the asteroid using the main spacecraft later this year, before returning to Earth in 2020. In the meantime, the rovers will survey Ryugu. Its low gravity means the rovers can't use wheels, and instead use momentum to 'hop' across the surface.

"I am proud that Hayabusa2 was able to contribute to the creation of this technology for a new method of space exploration by surface movement on small bodies," says Yuichi Tsuda, the project manager of Hayabusa2.

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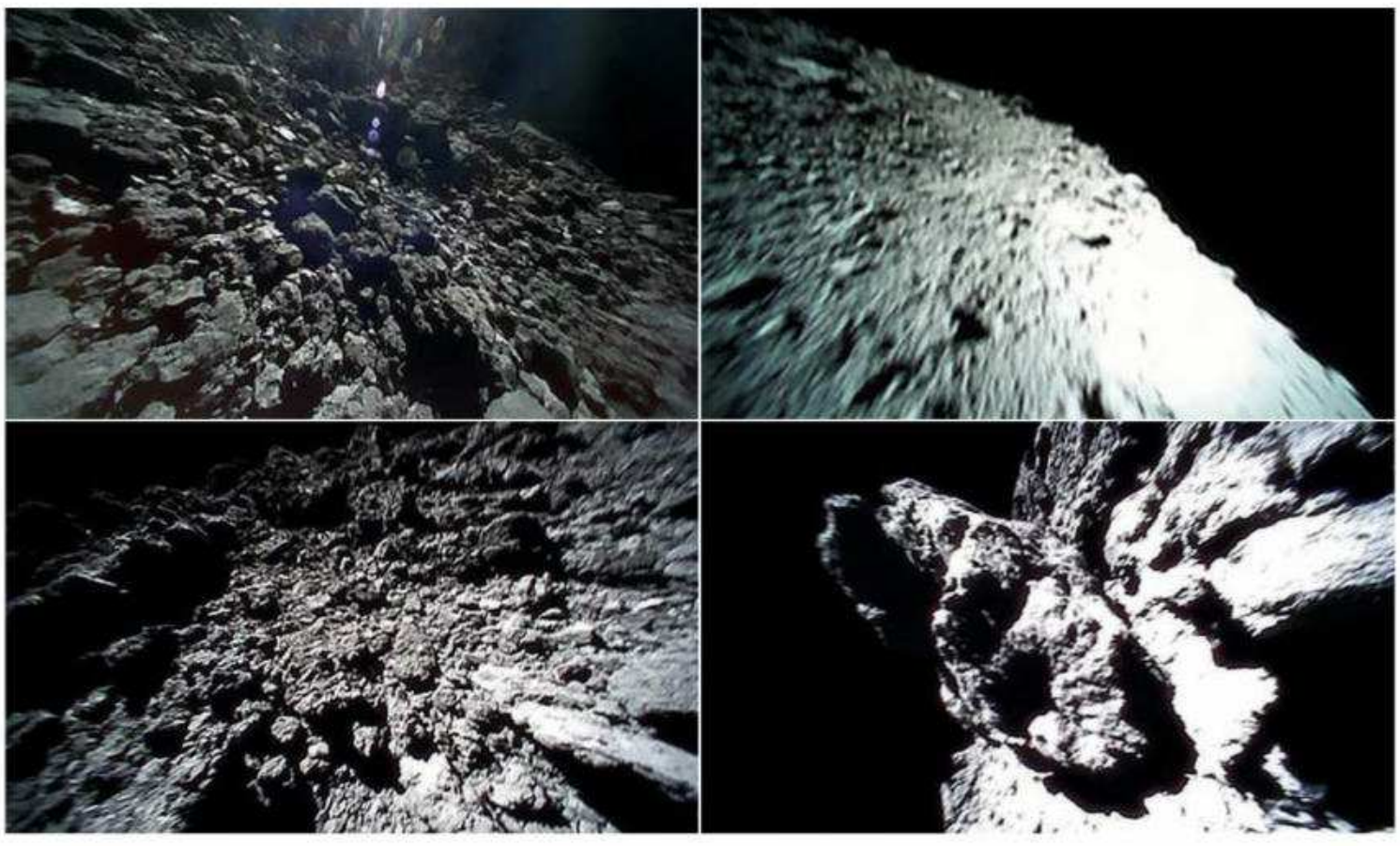


▲ Some of the first images of Ryugu's surface taken by the 'hopping' Rovers 1A and 1B on 23 September

NEWS IN BRIEF

UK COMPLETES SOLAR PROBE

This September, the European Space Agency's Solar Orbiter left the Airbus factory in Stevenage, UK where it was built. It is now heading for an ESA testing facility in Germany. The probe, due to launch in February 2020, will orbit the Sun once every five months, examining its magnetic field and solar wind. The Orbiter's observations will help astronomers interpret the Sun's inner workings, and understand why its magnetic poles flip once every 11 years.

EARLY PLANET SHAKE UP

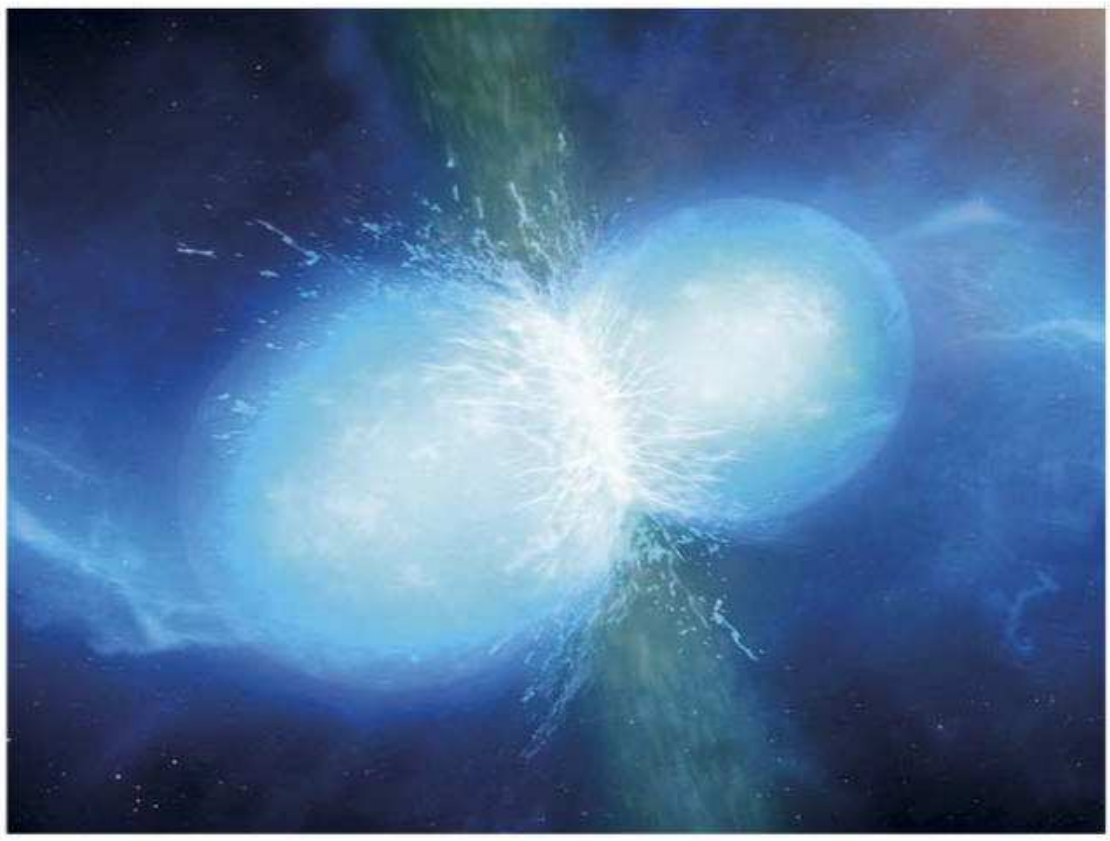
Recent research into the binary asteroid Patroclus and Menoetius points to a very early rearrangement of our Solar System. Most planetary scientists agree that the gas giants migrated to their current positions after forming in a different orbit, gravitationally upsetting the Solar System in the process. It's not clear when this happened, but the survival of a fragile binary like Patroclus-Menoetius suggests it happened within the first 100 million years of the Solar System.

CUTTING EDGE

Our experts examine the hottest new research

Heavy elements created by crashing neutron stars

These mighty stellar collisions do not appear to be the only source of these elements, though



UNIVERSITY OF WARWICK/MARK GARLICK

▲ **Could the collision of neutron stars be the source of 'r-process' elements, the creation of which may be a vital step towards life evolving?**

We are stardust. Most of the atoms in our bodies come from previous generations of stars, without whose presence none of us could exist, which is not to say that we understand the details. Astronomers are currently especially busy arguing over a site for the production of what are known as 'r-process' elements. These are elements such as barium and cerium, heavier than iron, and whose creation requires the rapid addition of neutrons – as many as 100 per second – to atomic nuclei. The conditions needed to create such a process require huge amounts of energy that only occur during some of the Galaxy's most dramatic events.

On 17 August 2017 the LIGO gravitational wave detector found a merger between two neutron stars, an event spotted and studied by more than 70 different telescopes, and we hoped it might give us the information needed to track down the source.

By observing such events, astronomers hope to work out what elements are produced where. Most of the light we see in a supernova, for example, is not from the explosion directly, but rather produced by the decay of unstable, heavy nuclei produced by the process. Combining observation with a bit of theory, the goal is to try to match the mix of heavy elements we see in the Universe around us.

The research paper I'm spotlighting this month is an attempt to take stock of where we are, especially now we've seen a neutron star merger. That single event – a kilonova – produced maybe as much as four per cent of the Sun's mass just in heavy, r-process elements. Its occurrence soon after the gravitational wave detector switched on also means that such events are most likely pretty common, though we need to observe for a while longer before we can be sure of that.

Even assuming that these things happen often, the paper's authors come to a surprising conclusion. Kilonovae just don't work as the only source of heavy elements. In particular, the authors study the presence of the otherwise obscure metal europium as a subtle test of what's going on; throughout the Milky Way disc, where we see more iron, we measure a

> "On 17 August 2017 the LIGO gravitational wave detector found a merger between two neutron stars – an event they've called a kilonova"

lower ratio of europium to iron, though a simple model using only kilonovae to produce r-process elements suggests that this ratio should be constant.

In other words, something is missing from the model. It's possible we don't properly understand kilonovae – after all, we've only seen one – and new observations will certainly help. But that one event certainly seemed to behave as expected. The alternative is to spice up the recipe for the early Universe with a little extra europium from some previously neglected source. The authors suggest that unusual supernovae involving stars with extreme magnetic fields might be capable of filling the gap. These are very rare now, but might, perhaps, have been common in the early Universe.

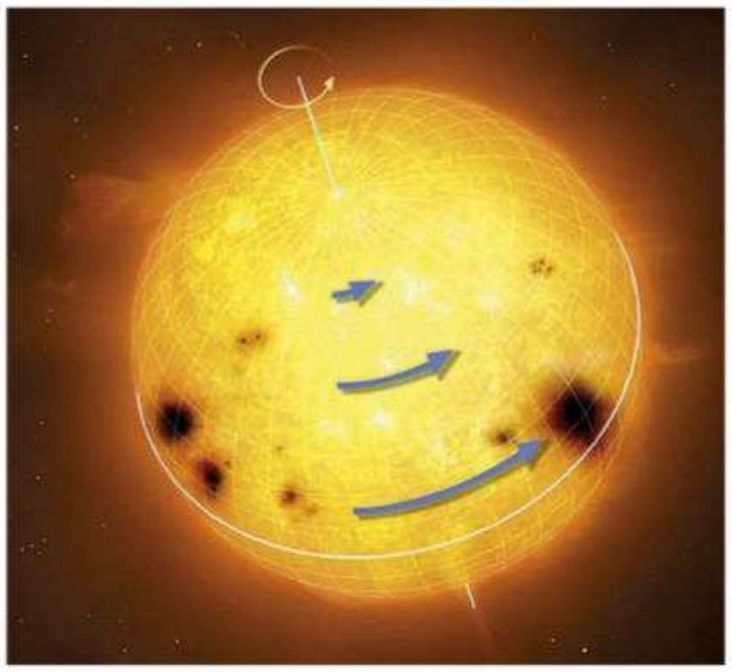
Is that the correct answer? I don't know. Getting the right answer here is a test of everything we think we know about the Universe's evolution, as well as the physics of some of the most extreme events ever to have taken place. That's why this work is so important and the recent discoveries so exciting.

CHRIS LINTOTT is an astrophysicist and co-presenter of *The Sky at Night* on BBC TV. He is also the director of the Zooniverse project

CHRIS LINTOTT was reading… *Neutron Star Mergers Might not be the Only Source of r-Process Elements in the Milky Way* by Benoit Côté, et al.
Read it online at: arxiv.org/abs/1809.03525

Stars may have a tell-tale twist

Their rotation could help our understanding of stellar magnetic fields



▲ The difference between the equatorial and polar rotation of some stars is far more extreme than our Sun's

A new study has found that some Sun-like stars twist more than expected. Unlike planets, stars rotate faster at the equator than at the poles; it is believed this phenomenon is responsible for the generating magnetic fields and sun- and starspots.

The rotation of the Sun is well-known, but when astronomers examined 13 similar stars they found several of them had rotational differences much larger than current theory predicts. The rotation was measured using a technique called asteroseismology, which uses surface vibrations to provide a window into what's happening deeper within the star.

"Information about stellar differential rotation is key to understanding the processes that drive magnetic activity," says Laurent Gizon, the director of the Max Planck Institute for Solar System Research, where the discovery was made.

www.mps.mpg.de

Curiosity stops transmitting science data

The Mars Curiosity rover is out of operation after an unknown fault caused it to stop transmitting information. The glitch was discovered by mission operators on 15 September, when the rover failed to send its science data back to Earth.

The rover is still transmitting 'real-time' data, which confirms that Curiosity's hardware is still operating normally. This would seem to suggest that the issue lies within the rover's computer. Engineers will attempt to identify the cause of the problem, and may switch to the back-up computer if it cannot be remedied.

With the Opportunity Martian rover also off-line at the time of writing, there are currently no working rovers on the surface of Mars.

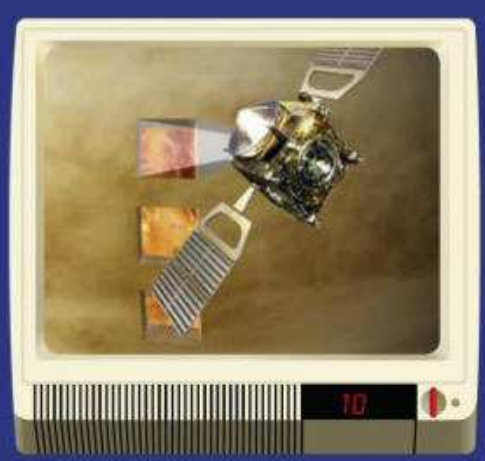
mars.nasa.gov/msl

▲ Curiosity first had a computer failure that led to it switching to its back-up six months into its mission in 2013

LOOKING BACK THE SKY AT NIGHT
6 November 2006

On 6 November 2006, *The Sky at Night* covered the work being done by the Venus Express spacecraft, which had arrived at the second planet from the Sun in April that year. The world had long intrigued astronomers, as its thick clouds shroud the planet from view. In the episode, Patrick Moore remarked how he and many others used to believe that beneath the clouds lay a verdant world. Though the Soviet Venera programme which ran from 1961 to 1984 dispelled this notion, in 2006 the planet still held many mysteries.

In November 2005, the European Space Agency launched Venus Express. On arrival, it used radar to pierce through the clouds, finding evidence of recent volcanism on the planet's surface. The probe's other instruments examined the Venusian atmosphere, helping scientists gain a better understanding of how planetary atmospheres work not just on Venus, but on other planets too, including Earth.



▲ The Venus Express revealed how volatile the atmosphere of Venus is

NEWS IN BRIEF

SPACE SAPLINGS

The UK Space Agency is currently seeking homes for saplings grown from seeds that Tim Peake took to the ISS. The seeds came from an apple tree at Isaac Newton's former house. "Now we need to find good homes for them across the UK to help as many people as possible find out about the intertwined stories of Newton, gravity, physics, space travel and horticulture. Maybe one of the trees will one day inspire the next Newton," says Jeremy Curtis from the UK Space Agency.

SPACEX'S FIRST PAYING CLIENT

Japanese billionaire Yusaku Maezawa announced on 20 September that he has reserved a seat on a SpaceX flight to take him and up to eight artists on a trip around the Moon. Currently scheduled to launch in 2023, the #dearmoon Project will take the group into lunar orbit to peer down on the Moon. Maezawa hopes the trip will inspire the artists to create works that will allow the public to share in the experience, and encourage the next generation of explorers.

CUTTING EDGE

Our experts examine the hottest new research

Mars could have been as cold in its past as it is now

Water may only have flowed across the surface of Mars for brief periods following cataclysmic events

NASA/JPL-CALTECH/UNIV. OF ARIZONA

▲ An aerial image – taken by the Mars Reconnaissance Orbiter – of Mars's Uzboi Vallis, believed to have been formed by running water

Some of the clearest signs that ancient Mars once sported huge amounts of flowing water on its surface are provided by networks of rivers. These valley networks have long-since dried up, but their distinctive forms carved into the landscape are both abundant and widespread across the southern uplands of Mars. They tell us that during the period in the planet's history when they formed – the late Noachian, which was around 4.1 billion to 3.7 billion years ago – the Martian environment was very different from what we find today.

But what exactly was the nature of the early Martian climate? Was it once very Earth-like, with conditions warm enough for a genuine water cycle of rainfall and evaporation, resulting in long-term lakes and rivers? Or was ancient Mars the same very cold, icy, planet we know today, with average temperatures well below the freezing point, the valley networks having been formed by short-lived melting episodes triggered by a volcanic eruption or asteroid impact?

Has Mars ever been much warmer and wetter, or has it always been inhospitably cold, bleak and dry? The answer to this question is not only of interest to planetary climatologists, but is also important for determining the chances of Mars ever having developed life of its own.

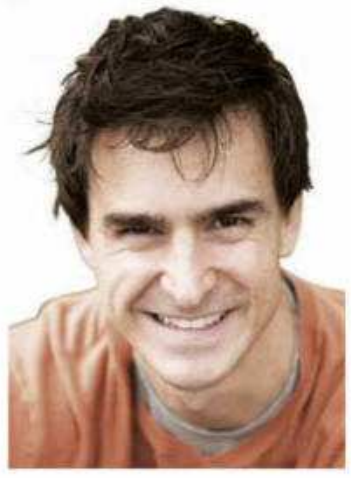
The preserved remains of the valley networks might also be able to provide insights into the ancient Martian climate. In recent years planetary scientists have used orbiter imagery and surface models to estimate the volume of liquid water that would have been necessary to carve out the valley networks, and over what timescales. The problem is, these calculations vary quite widely.

One research group estimated that eroding all of the valley networks would have required a volume of water equivalent to submerging the entire Martian globe to an average depth of almost 5km. If true, this would indicate that the flowing water must have been recycled many times down the valleys by evaporation and rainfall, and thus that ancient Mars was a great deal warmer. On the other hand, different studies calculated a required volume of water equivalent to only 3-100m globally, which could easily be explained by transient river activity in an otherwise very cold and icy climate.

These earlier estimates were based on certain assumptions and limited data sets and vary greatly from each other. So, to try to bring some clarity to the issue, Eliott Rosenberg and his colleagues at the Department of Earth, Environmental and Planetary Sciences, Brown University, have used more complete data for the volumes of the valley networks and an improved method for estimating the liquid flow that would have been required. They find that the minimum amount of liquid water needed to carve out the valley networks is around 640m globally.

> "A new study finds that the minimum amount of liquid needed to carve out Mars's valley network is around 640m globally"

This latest calculation sits in the middle of previous estimates. And it also seems to be consistent with either a warm, rainy ancient Mars, or a cold and icy climate. Intriguingly, the locations of many of the valley networks and lakes are where climate models predict ice layers would form in a cold scenario, and so they could be explained by meltwater running off surface ice. Perhaps ancient Mars was not as habitable as we might have thought.



LEWIS DARTNELL is an astrobiology researcher at the University of Westminster and the author of *The Knowledge: How to Rebuild our World from Scratch* (www.the-knowledge.org)

LEWIS DARTNELL was reading… *The volume of water required to carve the Martian valley networks: Improved constraints using updated methods* by Eliott N Rosenberg, *et al.* **Read it online at: www.sciencedirect.com/science/article/pii/S0019103517305900**

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Join us on our unique flights in search of the Northern Lights – a special experience not to be missed!

The Northern Lights' appearance can vary from a weak glow to a sky-filling spectacle, and our flights aim to eliminate some of the factors that can hamper a land-based aurora watching experience. Our expert team, led by award-winning astronomer Pete Lawrence, will facilitate pre-flight briefings highlighting the spectacular sights that will be visible from the plane window along with explaining why the aurora happens.

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- Light refreshments on board
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- Services of an Omega Holidays tour manager

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Sat 8 Dec 18	Edinburgh	**£240**
Fri 1 Feb 19	Humberside	**£265**
Sun 3 Feb 19	Glasgow	**£240**
Tue 5 Feb 19	Norwich	**£280**
Mon 25 Feb 19	Gatwick	**£240**
Tue 26 Feb 19	Southampton	**£240**
Wed 27 Feb 19	Birmingham	**£240**
Thu 28 Feb 19	Leeds Bradford	**£240**
Fri 1 Mar 19	Manchester	**£240**
Sun 3 Mar 19	Stansted	**£240**
Thu 7 Mar 19	East Midlands	**£240**
Fri 8 Mar 19	Cardiff	**£240**
Sat 9 Mar 19	Newquay	**£280**

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or visit **omegabreaks.com/nightsky**

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omegon®

1000 PHOTOS WITHOUT ELECTRICITY

MiniTrack LX2: The First Fully Mechanical Photography Mount

Saslong Night - Sassolungo da Col Raiser (Italy) – Photo: Cristian Fattinnanzi

NEW

Wide-field imaging, as depicted above, is possible with ease. The fully mechanical Omegon MiniTrack LX2 mount works just like a clock. No power necessary. No charging. No battery. Simply mount your camera onto the LX2 and wind it up. Easily capture wide-field images of the cosmos on your camera.

ball-head, camera and tripod not included!

£109

Clockwork Mechanics

The mount works like a clock with 60 minute tracking - all without power and batteries. Simply wind it up and get started.

Integrated 1/4" Threading

The MiniTrack fits every photography tripod and features two 1/4" threads. For example, you can connect the MiniTrack to a ball head and capture every part of the night sky.

Sleek and Compact

Whether on a flight or on the next night-time excursion. The MiniTrack fits into every bag and still leaves room for a nice tripod or a second tele-photo lens.

Up to 2 kg Load Capacity

The mount enables you to capture wide-field images of the night sky. From wide-angle to tele-photo lenses, so much is possible.

Powerful Spring System

The MiniTrack requires no counterweight, the spring system supports tracking. Spare yourself the weight and burden.

Polar Finder Tube

With the polar finder tube, you can calibrate the MiniTrack quickly to the polar star. More than enough for a rough alignment.

Scan for more info.

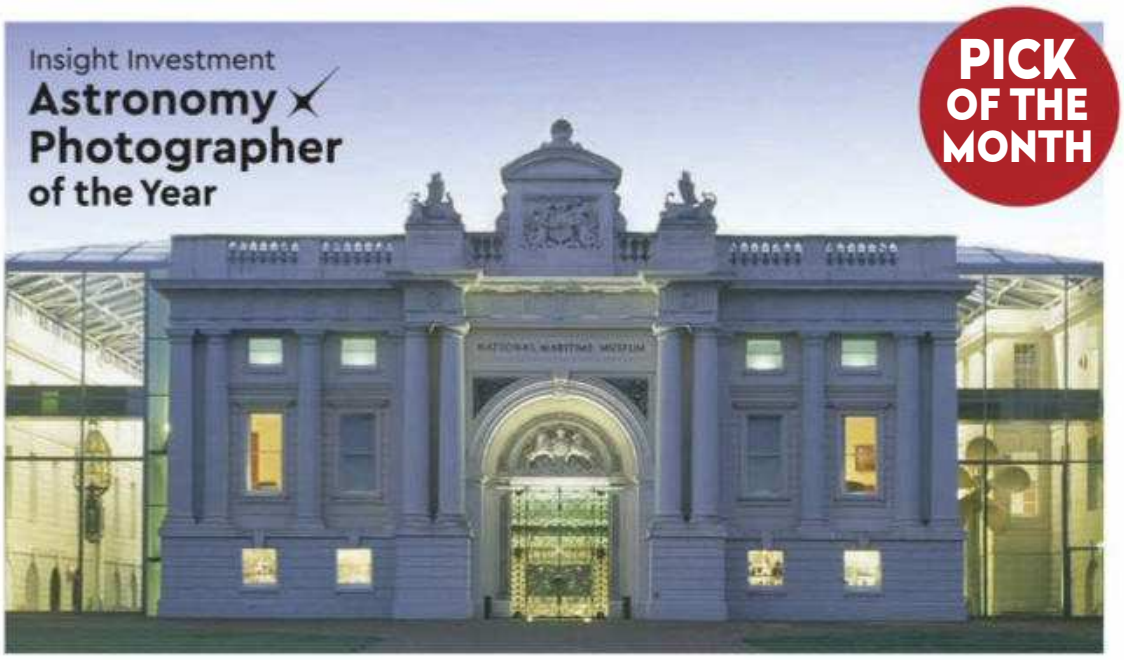
The Press says:

"The MiniTrack LX2 fulfills its promise and enables quick and spontaneous wide-angle astrophotography on trips, all without pesky power supplies." (Abenteuer Astronomie)

MiniTrack LX2	Art.-Nr.	Price in £
Photography Mount		
WxHxD in mm 210x78x30, weight 430 g	55040	**109**
Photography Mount incl. ball-head		
WxHxD in mm 210x78x130, weight 730 g	56106	**139**

What's on

Our pick of the best events from around the UK



▲ The National Maritime Museum will be full of stars to steer tall ships by from October

Insight Investment Astronomy Photographer of the Year 2018

National Maritime Museum, Greenwich, London, 24 October 2018 – 5 May 2019

The world's premier astrophotography competition celebrates 10 years of capturing the cosmos with a special exhibition at the National Maritime Museum. A new gallery space has opened for IIAPY 2018, which showcases the 31 winning, runner-up and highly commended images from this year's competition, as well as 69 of the top entries from the past decade.

The Insight Investment Astronomy Photographer of the Year competition has grown in size and scope over the 10 years since it began, and now includes categories for: astrophotographers under 16; those who prefer to capture their astro images online using robotic scopes located around the world; and the Sir Patrick Moore Prize for Best Newcomer. Along with astrophotos from these categories, expect stunning images of aurorae, skyscapes, stars, nebulae, galaxies, our Sun and Moon, planets, comets and asteroids.

The exhibition opened to the public following the announcement of the 2018 winners at a special ceremony held on 23 October.

Entry to the exhibition is £9 for adults and £5.85 for children if booked in advance, £10 and £6.50 respectively on the day. Advance bookings can be made via the IIAPY website. The exhibition is open daily from 10am until 5pm.
www.rmg.co.uk/royal-observatory/insight-astronomy-photographer-year

BEHIND THE SCENES

THE SKY AT NIGHT IN NOVEMBER

BBC Four, **11 November,** 10pm (first repeat BBC Four, **15 November,** 7.30pm)*

Bepi Colombo is a joint project from the European and Japanese space agencies

MISSION TO MERCURY

Bepi Colombo will be the first European mission to study the planet closest to our Sun. This month the team look at how the spacecraft was built, how it will make the journey to Mercury and what it will study once it gets there. Could Bepi Colombo unlock some of the secrets of the Solar System?

Check www.bbc.co.uk/skyatnight for subsequent repeat times

Warping space and time

Ballyclare High School Lecture Theatre, County Antrim, 5 November, 8pm

Dr Steve Barrett from the University of Liverpool presents a talk on black holes for the Northern Ireland Amateur Astronomy Society. Dr Barrett will separate science fact from science fiction, revealing what we know about the nature of black holes and how we can observe them. The talk will also look at black holes on the silver screen, asking, "Does Hollywood ever get it right?" This event is free, but donations are welcome on the night. Under-16s must be accompanied by an adult.
www.eaas.co.uk

Swansea Science Festival family weekend

National Waterfront Museum, Swansea, 3-4 November

Swansea University's science festival returns with a family weekend featuring 40 science exhibits and hundreds of activities. Mark Thompson's Spectacular Science Show reveals the strange properties of matter with fireballs and chemical reactions, while Professor Chris Allton explores Einstein's theory of relativity, black holes and the Higgs boson in 'Time – what a concept!' For the full programme, visit the festival website.
www.swansea.ac.uk/swanseasciencefestival/

The People's Star Party

Kielder Village camping and caravan site, Northumberland, 2-3 November

Get started in astronomy with this two-night beginners' event. Includes telescope tutorials, deep-sky and solar observing, astrophotography sessions and free talks. Attendees can bring their own kit for guidance on set up and how to observe. Tickets cost £15 for adults and £10 for children under 16. Pitch prices are not included. For a full list of prices, visit the event website.
www.kieldercampsite.co.uk/events

MORE LISTINGS ONLINE

Visit our website at **www.skyatnightmagazine.com/whats-on** for the full list of this month's events from around the country.

To ensure that your talks, observing evenings and star parties are included, please submit your event by filling in the submission form at the bottom of the web page.

Image courtesy of Joe Canzoneri

Perfect for the entry- level astronomer, the Atik Infinity is the first Atik CCD camera dedicated to video astronomy. It is supplied with our new, intuitive, in-house software dedicated to video astronomy, and is well suited to a broad range of telescopes, bringing the wonders of deep-sky imaging to your screen in just seconds.

Atik Infinity
Entry level

CCD TECHNOLOGY
IMAGING WITHOUT COMPROMISE

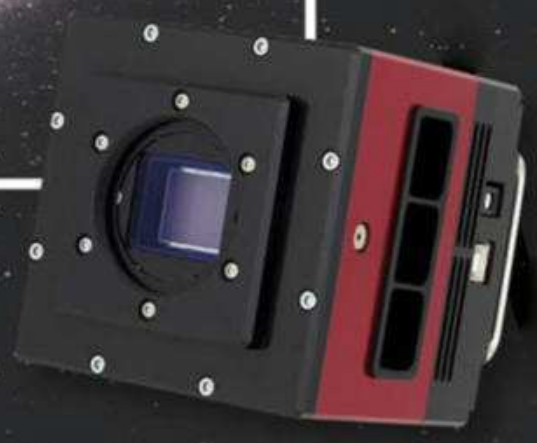
Atik 460EX
Mid range

Image courtesy of George Chatzifrantzis

The Atik 460EX is renowned for its perfect balance of sensitivity and resolution. It utilises a Sony ICX694, which is the sensor of choice for astronomers looking for the highest-quality data. Its efficiency and generous sky coverage make the 460EX one of the most versatile astrophotography cameras around, ideal for a large range of telescopes.

Atik 16200
Large Format

Image courtesy of
MASIL Imaging Team



The Atik 16200 boasts a sensor specifically designed for astronomy and having a generous 35mm diagonal. The 16million, 6µm pixel sensor can be freely binned so offers a huge amount of flexibility for both wide field and long focal length imaging. Argon purging, deep cooling and a mechanical shutter make this a camera for professionals and amateurs alike. The Atik 16200 is the camera capable of taking your imaging to the next level.

ATIK CAMERAS

See the full Atik range at
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A PASSION FOR SPACE

with **Catherine Mealing-Jones**

Why the space sector could be one of the UK's fastest-growing revenue generators in the next decade

Our space sector is a UK success story. Its employees are more than twice as productive as the UK average and growth has been extraordinary, with revenues tripling since 2000. It employs 38,000 people and supports at least £250 billion a year across the economy. More than a third of the sector's £13.8 billion revenues are generated by exports, and there is a significant ambition to boost this further by building new partnerships with space nations across the world. Between 2010 and 2016, UK public spending on space research and development increased by over 50% from £270 million per year to £410 million.

The real potential for further growth is in the services and applications that space can deliver, from improving farm management and reducing rail delays to enabling the cost-effective rollout of 5G. These can grow the UK economy when adopted by other sectors as they can both improve productivity and produce benefits to society.

We are also working to make the UK a one-stop shop for new satellite services. Global forecasts show an increase in demand for commercial satellite launch services from 2020s, and we are working to help UK companies seize this opportunity.

In July we announced £31.5 million of funding to support a spaceport in Sutherland, on top of £2m to support the development of horizontal launch, with potential spaceports in Newquay, Llanbedr and Glasgow. This funding, along with modern legislation – the Space Industry Act – makes it an exciting time for the UK space industry. New small satellite constellations are forecast to create a £10 billion global launch opportunity over the next 10 years.

An artist's impression of an Orbex launcher lifting off from Sutherland spaceport

ORBEX

Rocketing profits

This will help us reach our ambition for the UK space sector to grow its share of an expanding global space economy from its current seven per cent to 10 per cent by 2030, by which time the global space marketplace will be worth, conservative forecasts estimate, $600 billion per annum.

Space is also now recognised as providing critical national infrastructure to the UK. Commercial investment can complement this with new space capabilities and the global markets are there and accessible to UK businesses to sustain high levels of UK sector growth.

The 'New Space' era of cheaper access is being driven by a revolution in technology and business models delivered by entrepreneurs and commercial investment. The latest satellite network proposals are designed with many small satellites in constellations, delivering truly ubiquitous observation and connectivity from space. This trend is accelerating and the UK is well placed to take advantage of it. Commercial companies are exploiting strengths in services and entrepreneurs are interested in investing in the UK. Organisations including the UK Space Agency and the Satellite Applications Catapult will foster future growth.

Our support for the European Space Agency (ESA) is also an important part of our growth, enabling the UK to participate in major science and exploration projects and giving us access to R&D and expertise generated from ESA's €4.5bn annual budget. Participating in ESA's R&D programmes has underpinned UK competitiveness and European leadership in satellite communications, Earth observation and applications, and will continue to do so for many years to come.

CATHERINE MEALING-JONES is Director of Growth at the UK Space Agency, coordinating the Government's input into encouraging growth in the sector

Sega Toys Homestar Flux

Satin Black

Imagine enjoying the sky full of stars while sitting on your sofa. This dream can become reality with the Sega Toys series of home planetariums.

Flux is the most powerful and most advanced model available to date. Crafted in a satin-like finish, this powerful star projector is designed to be your first choice home planetarium.

Brilliant glass lenses and our brightest LED to date make everything look vibrant and sharp.
The indicated edges of a lunar crater surrounding the lens finish the look.

SEGA TOYS flx

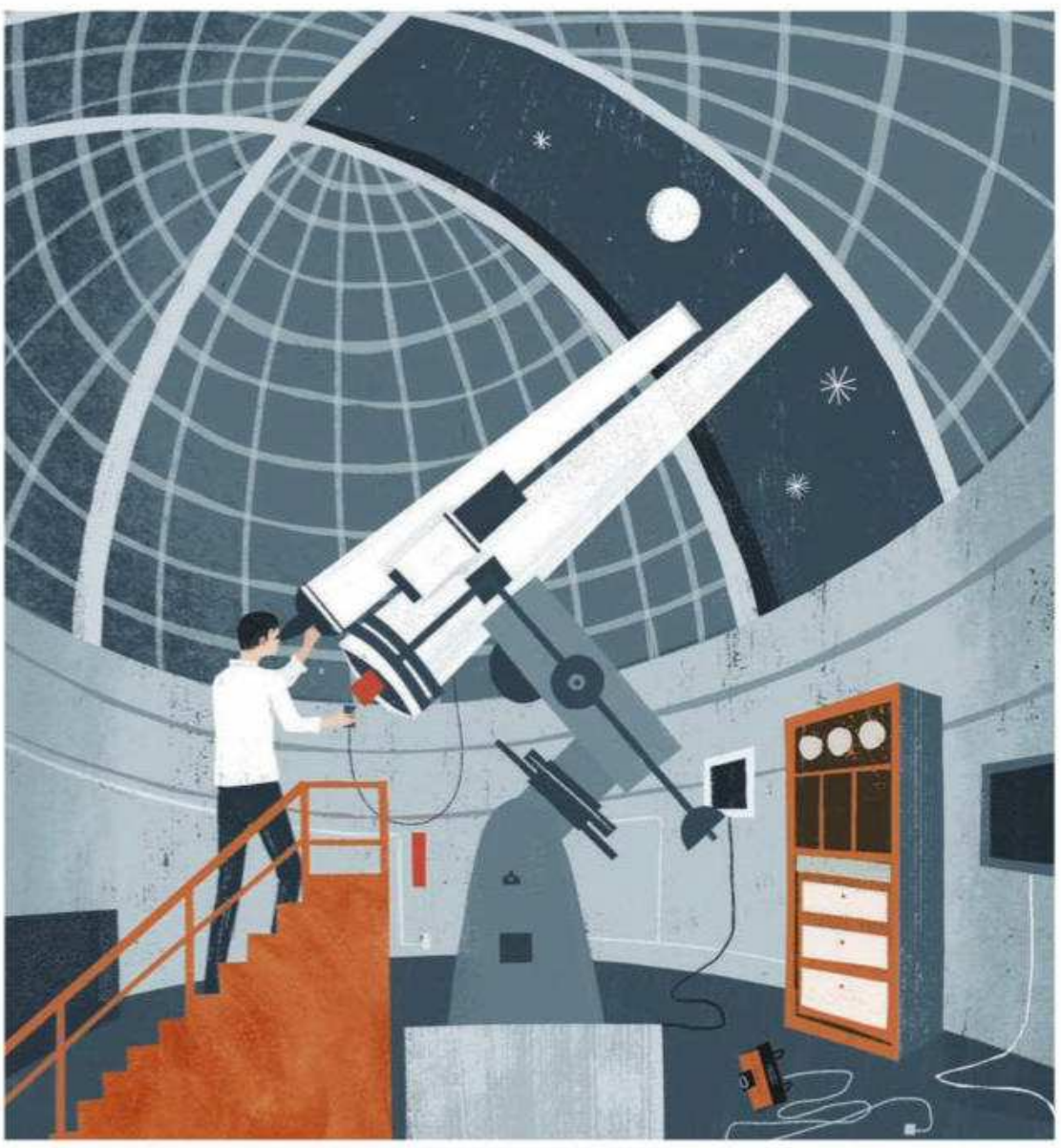
Brand New for Christmas 2018

www.segatoys.space 149GBP

FIELD OF VIEW THE AMATEUR ASTRONOMER'S FORUM

Drawn to the Universe

In the first of a new regular column **Paul Abel** reveals why, in the era of imaging, he still loves just looking



SAM KALDA/FOLIO ART

As I focused the splendid 12-inch Zeiss refractor on to the planet Saturn, our American host said, "I think it's great you still look!" In the balmy heat below, the general chaos of Los Angeles continued, seemingly indifferent to the bright planets of Mars, Jupiter and Saturn now dominating the rapidly darkening sky. They were much higher here than in the skies of the UK and that was the reason for our visit to the magnificent Griffith Observatory. I waited for the inevitable question, and it arrived punctually: "Can I ask, why do you still look rather than image?"

I get asked this a lot and normally I have a selection of stock answers, but on this particular occasion, while watching the turbulent cloud tops of Saturn, I returned to the question anew. Without too much prompting, the answer appeared: I do it because I love it – that is, after all, why I am an amateur astronomer!

There was a time, before smartphones, CCDs and photography when the visual observer dominated practical astronomy. These veterans of a bygone era ventured out to their telescopes in much the same way that Columbus embarked on a mission to the New World. They were explorers of the next great frontier of human civilisation, for nothing was really known about the Solar System.

Over time technology advanced and brought about the necessary revolution in astronomy. Spacecraft revealed the planets to be very different places, in many ways more remarkable and stranger than we first thought. The canals of Mars and active lunar volcanoes suddenly seemed like quaint romantic ideas, but we should put them in context; they were the products of the first serious attempts at Solar System exploration, limited by small ground-based telescopes.

This philosophy of exploring the Solar System for oneself still resonates with me today. Of course I love to see those remarkable high resolution images that amateurs now produce, and if I were a planetary scientist I would find these results useful. I still think it's remarkable that details can now be captured on Jupiter's moons.

Being an amateur provides me with a different motivation for being at the telescope, though; it is still based in science but has the optimism of the explorer, too. In the same way that a high resolution photograph of the Grand Canyon is no substitute for actually being there, so it is that I find a much deeper connection with astronomical objects by drawing them and studying them visually.

Thankfully I have never seen canals on Mars, but every so often I look at the Martian deserts and recall Percival Lowell's attempts to understand the Martian civilisation he honestly thought was there. The Mars of today is very different from the one of Lowell's era, and yet across the gulf of time we are in some way connected by this desire to explore and see for ourselves the wonders of the Solar System, and that is the main reason why I still look.

PAUL ABEL is an astronomer, writer and *Sky at Night Magazine's* Virtual Planetarium co-host

Interactive

EMAILS ◢ LETTERS ◢ TWEETS ◢ FACEBOOK

Email us at **inbox@skyatnightmagazine.com**

This month's top prize: four Philip's books

PHILIP'S

The 'Message of the Month' writer will receive four top titles courtesy of astronomy publisher Philip's: Robin Scagell's *Complete Guide to Stargazing*, Sir Patrick Moore's *The Night Sky*, Mark Thompson's *Stargazing with Mark Thompson* and Heather Couper and Nigel Henbest's *2019 Stargazing*.

Children are our future

MESSAGE OF THE MONTH

▲ John's images of Saturn and Mars using an 8-inch Sky-Watcher and ZWOASI120MC camera

So pleased that the Martian surface is clearing. The latest results from my 8-inch Sky-Watcher and ZWOASI120MC camera with 2x Barlow show reasonable results, despite low altitude and heat from surrounding buildings. This has prompted me to make contact with a college in the next village as they have an observatory for school use and occasionally have open nights for the public. I now have contacts with the organiser and have regularly donated my copies of *BBC Sky at Night Magazine*, which they inform me have been avidly read by the pupils after exam time. Hopefully it will encourage them to pursue this great hobby.

John Consadine, Dereham, Norfolk

Great to hear our back issues are being so thoughtfully recycled, John! ***– Ed***

Tales from THE EYEPIECE

This month's tale comes from David Arundel of Birmingham Astronomical Society

Beethoven was a small black and white cat who seemed to own the whole district where I live. He got up to all sorts of mischief, including calling in for bacon and eggs around breakfast time at a neighbour's house.

One night whilst observing the Moon with my 8¾-inch Dobsonian, Beethoven decided to visit me and see exactly what I was up to. He thought it would be a good idea to sit inside the Dobsonian box mount, and it turned out that his little extra weight helped to make for a more stable setup.

Beethoven has sadly passed away since, but I feel with all his antics he has earned some form of immortality, and I often think about him while observing the sky at night.

Email your own tales to: TalesfromtheEyepiece@themoon.co.uk

Tweets

Paul Moane
@paulmoane • Sep 14
Milky Way above, captured from Rossglass Beach, County Down. Pic by @paulmoane @StormHour @GrahamPenrose2 @ThePhotoHour @WinterExpert @PictureIreland @skyatnightmag

A matter of time

Please convey my thanks to Bev (Interactive, October 2018) for his diplomatic way of correcting my error. I have fixed my True North Solar Compass and used it to align my telescope and mount. Using the sundial time correction form at www.ppowers.com/EoT.htm and the time correction at my local meridian, I noted that the Equation of Time (EoT) on 16 July – when I wrote my first letter (Interactive, September 2018) – was –6m 5s, and without correcting for this and my local meridian my alignment was out by 4.5°. How could I have not accounted for my local meridian? I set this every time I power up my mount. I've also read about the EoT but stored the information in some deep inaccessible recess of my mind. My only excuse is never trust a meteorologist – they can never get the weather right either!

Archie Howitt, Edinburgh

SOCIETY in focus

On 15 September, in the wake of our spectacular and extremely well-attended 1,000th society meeting just one week earlier, members of York Astronomical Society were on hand once again to entertain the public. On this occasion it was in the beautiful surroundings of Rievaulx Terrace in North Yorkshire, owned and operated by The National Trust.

Despite some sunshine during the day, as night drew in and we set up our instruments things were not looking good. Around 65 members of the public arrived at 7pm and were kept entertained by looking at the telescopes and photographs on members' laptops. The main event started at 7.30pm and the group was split in two. One group went for a nocturnal walk, visiting moth traps and detecting bats. The other half sat in the undercroft of the beautiful Ionic Temple to listen to an autumnal astronomy talk by one of society's members.

Unfortunately for the public, the night sky simulation show was the nearest they would get to seeing actual objects in the sky. Although there were some fairly large gaps, the steady winds meant that we had only fleeting glimpses of the Plough in its entirety and the Summer Triangle overhead. This still wowed the crowds, who had been introduced to them in the talk, and everybody went away having had an enjoyable night.

The York Astronomical Society will continue its programme of public outreach over the winter with regular star parties at York Racecourse, and at the new home of our observatory at Beetle Bank Farm on the eastern outskirts of the city. We also have two formal meetings per month held at the Priory Street Centre in York.

Martin Whipp, York Astronomical Society

To find out more about the society visit: www.yorkastro.org.uk


Easel does it

There's an art to it

I recently found myself under dark skies in the Tarn region of France, without my trusty portable tripod. Luckily there was a painting easel to hand which came in handy for setting up my camera for some long(-ish) exposures of the Milky Way. Thanks for a great magazine.

Brendan Malone, Rugby

Exit Excursions

Oh no! One of my favourite features in the magazine – Jon Culshaw's Exoplanet Excursions – seems to be coming to an end. They always so fired the imagination, and reliably sent a shiver down the spine. No offence to Jon, but can we fix the Perihelion and blast him off on a similar adventure soon?

Jon Dixon, Suffolk

After five years and almost 60 voyages, the intrepid explorer of distant worlds is focusing on Earthly projects. Replacing it is Field of View (see page 25), a place for opinion and reflection on all aspects of amateur astronomy. Readers are encouraged to get in touch if they have ideas for the new column. ***– Ed***


Loughton Astronomical Society

A cordial invitation

We are inviting *BBC Sky at Night Magazine* readers to join the Loughton Astronomical Society (LAS), the home of all things astronomical in West Essex, on the occasion of our 50th anniversary on 10 November 2018. Originally formed as an evening class to teach mirror making, the LAS continues to thrive with an active weekly programme and also organises the Autumn Equinox Skycamp at Kelling Heath. Our celebrations will include displays, demonstrations, an indoor planetarium and lectures from top astronomers in the afternoon. Please visit **www.las-astro.org.uk** for more details and the opportunity to purchase tickets.

Brian Mortony, Loughton Astronomical Society

Meanwhile on FACEBOOK...

WE ASKED: What are your top tips for keeping warm while observing?

Paul A Hatton
Fatten up with plenty of food.

Joan Williamson
Thermal socks and underwear as well as thick-soled boots. A windproof, warm but thin but jacket so you don't look like a Tellytubby.

Jonathan White
A beach tent is ideal. It can help shield wind and keep a bit of heat in while allowing you enough space for your equipment.

Andrew Gray
Piece of old carpet to stand on.

Alastair Woodward
Astrogloves and a large tumbler of whisky.

Wendy Keys
Sheepskin gloves and a hottie or hot water bottle inside your jacket.

Michael John Fisher
Move to Tenerife.

Natalia Garrett
Hand warmers in my shoes and gloves; a hot water bottle in my jacket; and a big warm hat. Obviously a giant thermos of tea, too.

Kevin Jackson
Remote control of your scope while you sit by the fire.

Ricky Bryceland
Sit in the house and watch *Sky at Night* on the telly!

Martin Bailey
An ice bath before leaving the house. It feels tropical outdoors then.

OOPS!
On page 34 of the October 2018 issue the distance to M45, The Pleiades, was given as 440 million lightyears. The correct distance is 440 lightyears.

BBC

Sky at Night MAGAZINE

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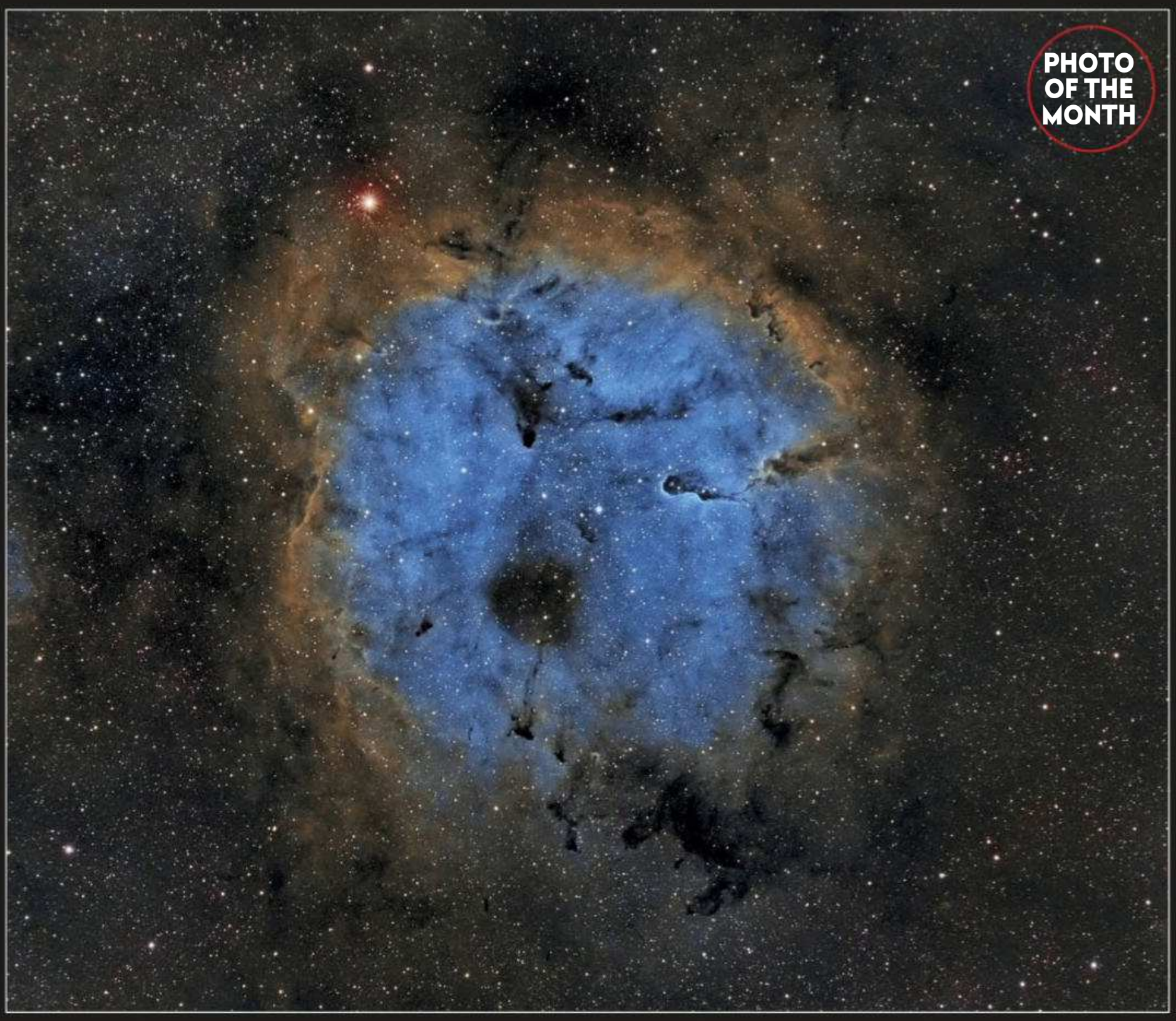
BBC Sky at Night MAGAZINE

Hotshots

This month's pick of your very best astrophotos

YOUR BONUS CONTENT

A gallery containing these and more of your stunning images



▲ IC 1396

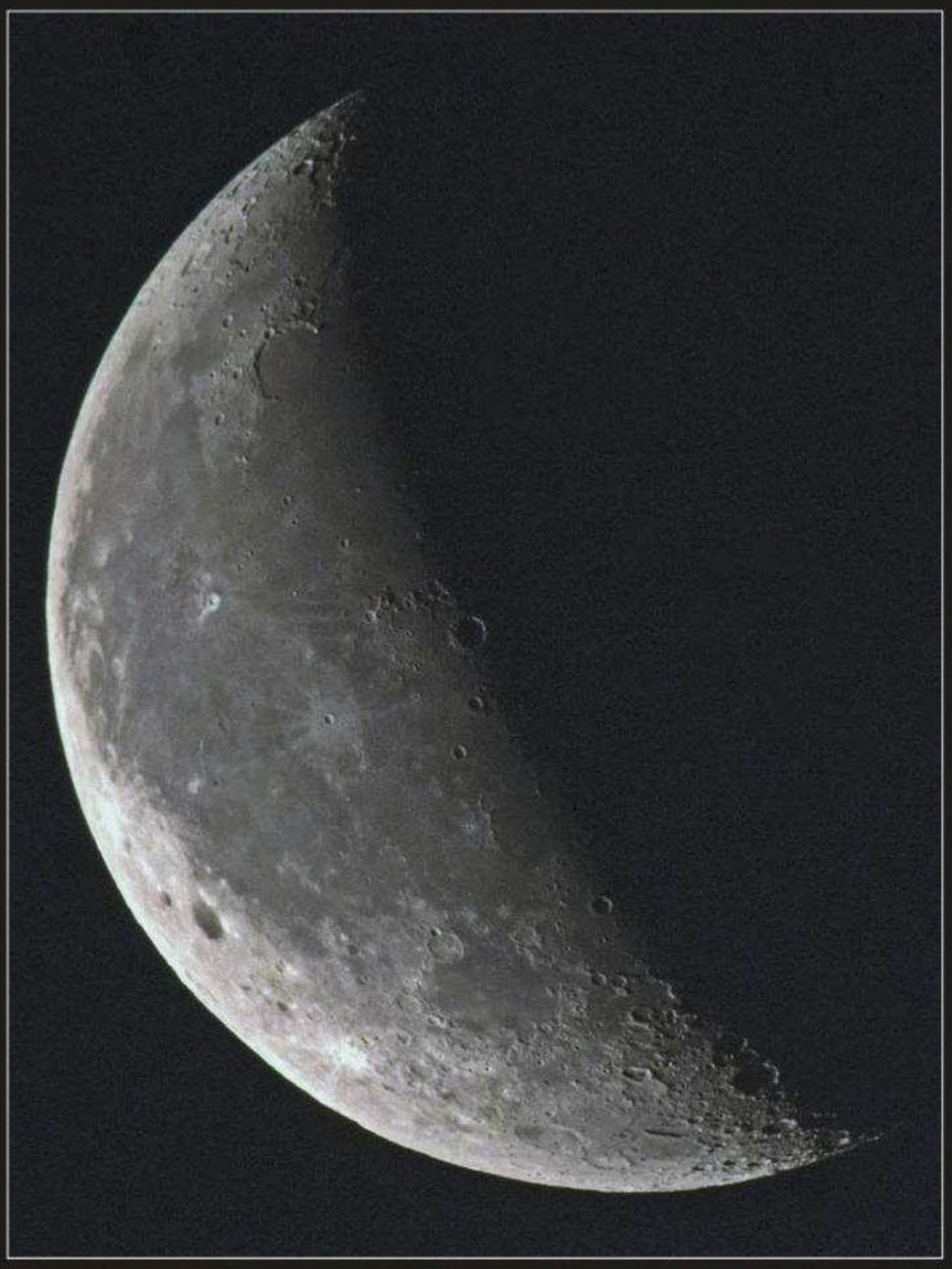
ADAM SHEWAN, YORK, AUG 2017, AUG 2018

Adam says: "This image has been over a year in the making. I collected the hydrogen alpha data last year but even while I was processing I knew it needed OIII and SII. This year I collected additional data to create a final colour image."

Equipment: Atik 460EX mono CCD camera, Sky-Watcher HEQ5 Pro SynScan mount, Samyang 135mm f/2 lens, Ha, SII, OIII filters **Exposure:** 6h Ha, 3h OIII, 3hr SII **Software:** PixInsight, Photoshop

***BBC Sky at Night Magazine* says:** "This is a fantastic astrophoto and a worthy winner. We love how the glowing colours of the nebula contrast with the well-defined swirls of dark dust, including the Elephant's Trunk Nebula at three o'clock."

About Adam: "The first time I looked through a telescope I loved it and when I realised I could image what I was seeing my interest was really piqued. I started with a DSLR on a fixed tripod and my first image was M31 using a 50mm lens. When I saw that little smudge of light on the viewfinder, the imaging bug bit! These days I image using both DSLR and CCD cameras. I tend to use my telescope for galaxies and my lenses for nebulae."



◀ Copernicus at the terminator

MARC CHARRON, AYR, 4 SEP 2018

Marc says: "I took the image about 30 minutes after sunrise, hoping to capture shadows inside some of the larger craters in the southern highlands. I wasn't expecting to see Copernicus sitting astride the terminator, yet there it was."

Equipment: Nikon D5300 DSLR camera, Altair Astro Starwave 70ED triplet refractor, Manfrotto tripod **Exposure:** 1/320" **Software:** Photoshop Elements 13

▲ Mars

AGAPIOS ELIA, NICOSIA, CYPRUS, 4 AUG 2018

Agapios says: "The dust storm on Mars was still going, so the planet displays reduced contrast. Some major features are well displayed like Syrtis Major, the southern polar region and the Hellas impact basin."

Equipment: ZWO ASI224MC camera, Celestron C9.25 Schmidt-Cassegrain, Celestron Advanced VX mount **Exposure:** 2,700 frames, 300fps **Software:** WinJUPOS, Photoshop

The Cygnus Wall ▶

ALAN RITHAMER, HULL, 4-5 AUG 2018

Alan says: "After reading various forums I decided to increase the exposure time on the camera to three minutes on the Ha filter, using the Unity Gain on the camera setting at –20. A high-pressure weather system and clear skies were key to this image, plus a helping of luck!"

Equipment: ZWO ASI 1600MM cool camera, Sky-Watcher Esprit 100 ED Pro triplet refractor, Sky-Watcher NEQ6 Pro SynScan mount **Exposure:** 30x3′ Ha, 30x2′ OIII, 30x2′ SII **Software:** DeepSkyStacker, PixInsight, Photoshop

▲ A Perseid and the Milky Way

TREASA GIBLIN FRAZER, MOOR LOUGH, COUNTY TYRONE, 8 AUG 2018

Treasa says: "I heard the Perseids was happening so I headed out to the lake to see if I could catch a few meteors along with the Milky Way. In the image is my mate Catherine on her bike, which had two flat tyres so we couldn't go too far!"

Equipment: Canon EOS 5D Mark II DSLR camera, Rokinon 14mm f/2.8 lens **Exposure:** ISO 2000, 25" **Software:** Photoshop, Lightroom

◀ North America and Pelican Nebulae

ANDREW KNIGHT, BEDFORDSHIRE, 1-7 JULY 2018

Andrew says: "I'm happy with the details I captured, considering my DSLR is unmodified, and it's nice to see these objects in a wider view than I can get with my Sky-Watcher 150P-DS."

Equipment: Nikon D5200 DSLR camera, William Optics Zenithstar 61 apo refractor, Sky-Watcher AZ-EQ6 GT mount **Exposure:** ISO 800, 85x180", 32x300" with dark, flat and bias **Software:** DeepSkyStacker, PixInsight

Veil Nebulae ▶

CHARLES THODY, LINCOLNSHIRE, 2-3 SEPTEMBER 2018

Charles says: "Having built an observatory over the summer I was able to image over more than one night, capturing data before the Moon rose."

Equipment: Canon EOS 40D DSLR camera, Altair Starwave 80ED refractor, Sky-Watcher NEQ6 Pro mount **Exposure:** ISO 1600, 5x420", 5x300" 5x240" each region **Software:** Nebulosity, Photoshop

▼ The Andromeda Galaxy

CARL GOUGH, LITTLEHAMPTON, 14, 18 AUGUST 2018

Carl says: "I started astrophotography mid 2017 after seeing some amazing images by others. M31 is my best to date."

Equipment: ZWO ASI 1600MM mono camera, TS Optics 80mm triplet apo refractor **Exposure:** 60x60" each for R, G & B; 4h for luminence **Software:** Sequence Generator Pro

The thrilling 30

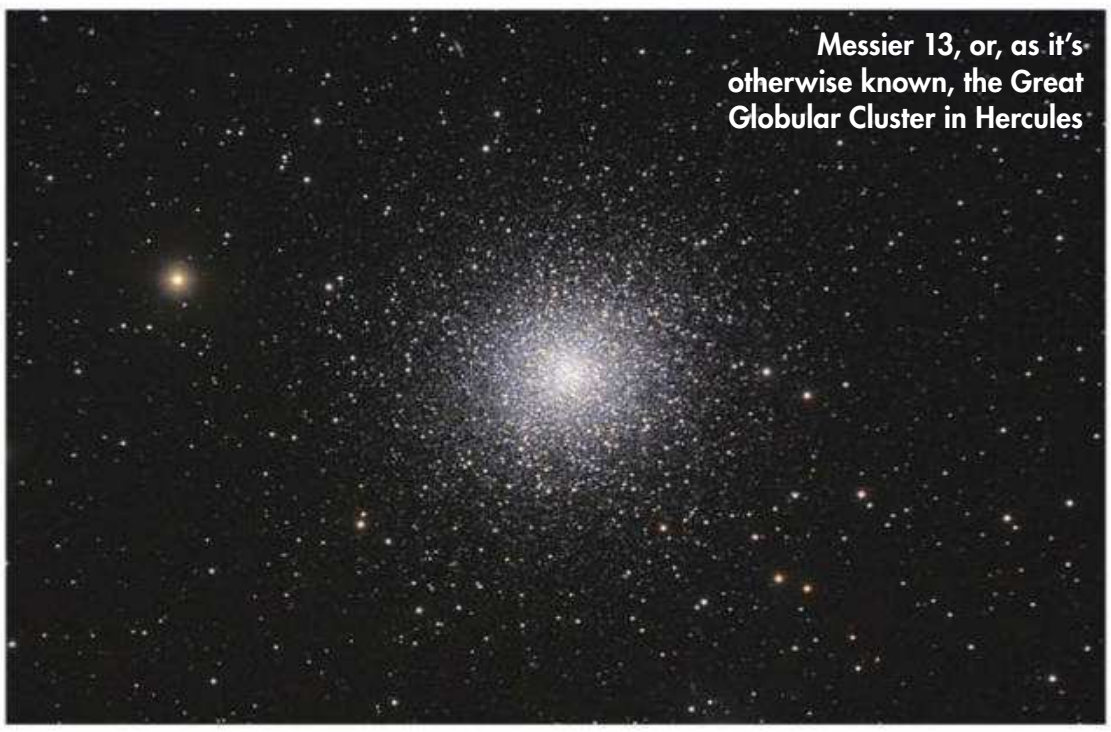
A BEGINNER'S SPECIAL

New to stargazing and not sure where to point your scope? Will Gater reveals 30 captivating celestial sights for November

The Pleiades is the easiest open cluster to spot with the naked eye

ABOUT THE WRITER
Will Gater is an astronomy writer and presenter. Follow him on Twitter at @willgater or visit willgater.com

With the chilly nights really beginning to bite this month, you'd be forgiven for preferring the warmth of the sofa to an evening spent leaning against the cold metal of a telescope. But shun the eyepiece in November and you'll miss out on one of the standout months for stargazing in 2018. With planets on show, a meteor shower, a comet and an asteroid at opposition – all on top of a night-time sky that boasts some of the best late summer to early winter targets – there's a wonderful array of sights overhead that'll eclipse anything on telly. Here we've selected 30 phenomena that will appeal specifically to anyone new to astronomy, and more experienced stargazers should find the list an enjoyable appetiser for their own observations throughout the month. So fire up your favourite planetarium software or grab a star atlas and get ready to hunt down the thrilling 30.



Messier 13, or, as it's otherwise known, the Great Globular Cluster in Hercules

Saturn

It might be past its best for the year, but, if you can, look for Saturn at the start of the month when it will be hugging the horizon in the southwest after evening twilight has faded. In all our years of stargazing we've never come away from a view of Saturn at the eyepiece with anything like a sense of regret, so that's why we're kicking off this guide with the mesmerising ringed planet.

Messier 13

From Saturn we turn to an object that is higher in the west at the beginning of the month. Messier 13, in Hercules, is a 'globular cluster', a spherical mass of stars sitting outside the disc of our Galaxy. In a small telescope it looks like a blurred ball of light while in larger scopes it has a sparkling 'granular' appearance.

Epsilon Lyrae

Epsilon (ε) Lyrae – which is less than 2° from the bright star Vega, in the constellation of Lyra – is a star with a secret… or rather four. A low magnification eyepiece will show it as two close points of light, but increase the magnification and each of those points is revealed to be a pair of stars orbiting each other.

The Coathanger Cluster

A good pair of binoculars is all you'll need to catch the beautiful Coathanger Cluster among the dark dust lanes and star fields of the Milky Way. It lies just over a third of the way between the bright stars Altair and Vega.

Neptune

While Saturn and Mars can be seen clearly with the naked eye in November's skies, the fainter ice giant Neptune will require binoculars or a telescope. It's currently about 2° to the east, roughly, of the star Lamda (λ) Aquarii. Through a medium-aperture telescope at high magnification you should be able to see it as a small, bluish disc.

Albireo

As Cygnus soars high in November's early-evening skies look to its 'head' where you'll find the star Albireo (Beta (β) Cygni). Turning a telescope on it will reveal an exquisite pairing of stars – one gold, one bluish. Data from the Gaia mission recently revealed that this close stellar duplet results from a chance alignment, as the stars are not physically near to one another. ►

ISTOCK, GÜNTER KERSCHHUBER/CCDGUIDE.COM, HANNES BACHLEITNER/CCDGUIDE.COM, JOHANNES SCHEDLER/CCDGUIDE.COM

▲ The Coathanger Cluster isn't actually a cluster at all but a chance alignment of stars

◄ Albireo is one of the best-contrasting double stars because of their vividly different colours

The side-on spiral of the Andromeda Galaxy is one of the most distinctive deep-sky objects

"If you can get out to a dark-sky site you can glimpse M31 – 2.5 million lightyears away – with the naked eye"

The Garnet Star

If Albireo has whet your appetite for stars with striking colours then Mu (μ) Cephei, the Garnet Star, is another you'll want to track down. To find it in binoculars use the stars Sadr (Gamma (γ) Cygni) and Deneb (Alpha (α) Cygni) in the constellation of Cygnus, the Swan, as pointers to send you scanning along the Milky Way. As you reach Cepheus, the King, Mu Cephei should stand out easily with its superb ochre tint.

The Blue Snowball Nebula

Planetary nebulae are the glowing, ejected remains of stellar atmospheres left behind when stars with masses similar to our Sun come to the end of their lives. This month there's a beautiful example on show in the form of the Blue Snowball Nebula, NGC 7662, which can be found with a medium-to-large aperture telescope just over 4° east of the star Omicron (ο) Andromedae.

The Andromeda Galaxy and NGC 205

Of all the deep-sky objects in November's skies, few inspire wonder quite like the Andromeda Galaxy, Messier 31. If you can make your way out to a dark-sky site you can glimpse this vast conglomeration of stars – 2.5 million lightyears away – with just the naked eye. With a good pair of 15x70 binoculars, under those same dark skies, you should be able to pick out its satellite galaxy, NGC 205, as a smudged dot of light close to the elliptical form of M31.

Earthshine and a '3D' Moon

When the Moon is showing a thin crescent you can sometimes see a beautiful effect caused by sunlight reflected off the cloud tops and oceans of Earth illuminating the shadowed portion of the Moon. This 'Earthshine', combined with the brightly lit crescent, can give a striking, apparently three-dimensional view to the Moon's globe. Look for it during early-evening darkness on 10 and 11 November.

The Double Cluster

The Double Cluster – made of the open star clusters NGC 884 and NGC 869 – is an enchanting sight in a telescope with a low-magnification eyepiece. It's actually visible to the naked eye, but if you're using a scope you can star-hop to it by scanning west from 3rd magnitude Eta (η) Persei until you hit the star 9 Persei; then head north by just over 1°.

Lunar craters Catharina, Theophilus and Cyrillus

On the night of 13 November the spectacular lunar crater trio of Catharina, Theophilus and Cyrillus is well illuminated, close to the Moon's terminator. A small telescope is ideal for exploring them, particularly the impressive terraced walls inside Theophilus.

▲ **The Blue Snowball Nebula looks like an out-of-focus green star through smaller scopes but larger scopes will pick out its dim (mag. +13) central star**

► **Craters Theophilus (top), Cyrillus (middle) and Catharina (bottom), thrown into relief by the nearby terminator**

WILL GATER X 4, JOHANNES SCHEDLER/CCDGUIDE.COM

Clusters in Cassiopeia

Nestled within the star fields of the Milky Way, Cassiopeia boasts several attractive open star clusters, and with the constellation practically overhead at around 10pm this month it's a perfect time to explore some of them. One of Cassiopeia's real gems is Messier 103, which is a pretty sight in a modest scope using a magnification of between 80-100x. It lies about a degree northeast of the bright star Delta (δ) Cassiopeiae. Similarly, slewing southwest to nearby NCG 457 is another sight not to miss.

Earth's shadow

On a crisp and clear autumn evening look towards the eastern sky just after the Sun has set in the west. If the conditions are right you'll see a dark, blue-grey swathe of sky above the horizon. This is Earth's shadow projected out into space. Above it you'll see a pinkish band of back-scattered sunset colours known as the 'Belt of Venus'.

The Leonid meteor shower peak

The Leonid meteor shower reaches its peak this month so keep an eye out on 17 November for shooting stars heading from the direction of the head of Leo, the Lion. For more information about this shower see the Sky Guide on page 53.

The Cygnus Rift

One of the most striking sights in November's night skies isn't a glowing nebula or sparkling star cluster but the silhouette of some of the vast tendrils of dust and gas that thread through the disc of the Milky Way. The Cygnus 'Rift', as it's known, appears as a dark lane winding its way across the bright star fields that dominate the constellation of the same name.

▲ The blue-grey of Earth's shadow just above the horizon with the pinkish Belt of Venus forming the next tier up

Plato and the Lunar Alps

As the Moon becomes more prominent in the night sky towards the middle of the month it brings with it many fine telescopic sights. One of our all-time favourites through a small scope lies on the northern shore of the Mare Imbrium, where the smoother basalt plains of the lunar sea meet the spectacular landscape around the smooth-floored crater Plato and the rugged lunar Alps. The nights of 16 and 17 November will see this region particularly well illuminated.

The Pleiades

After midnight around the middle of November, Taurus sits high in the southern sky offering the chance to catch an early view of the winter sky's finest open star cluster, The Pleiades. Binoculars are all that you need to really enjoy this beautiful target. ►

▼ The Cygnus Rift looks like a dark river that runs through the Milky Way but is actually dust clouds obscuring our view of it

▲ **The apparent diameter of a 22° lunar halo is roughly the size your hand held at arm's length**

"A lunar halo is formed when moonlight is refracted by tiny ice crystals suspended within thin clouds drifting overhead"

Messier 37

Later in the month deep-sky observing becomes more difficult as the bright Moon interferes with the fainter targets. Before it does, be sure to catch a few of the fine star clusters that litter the Milky Way in Auriga and Perseus. Messier 37 in Auriga is a perfect example and can be found by scanning about 4° east from the star Chi (χ) Aurigae with a low-magnification eyepiece.

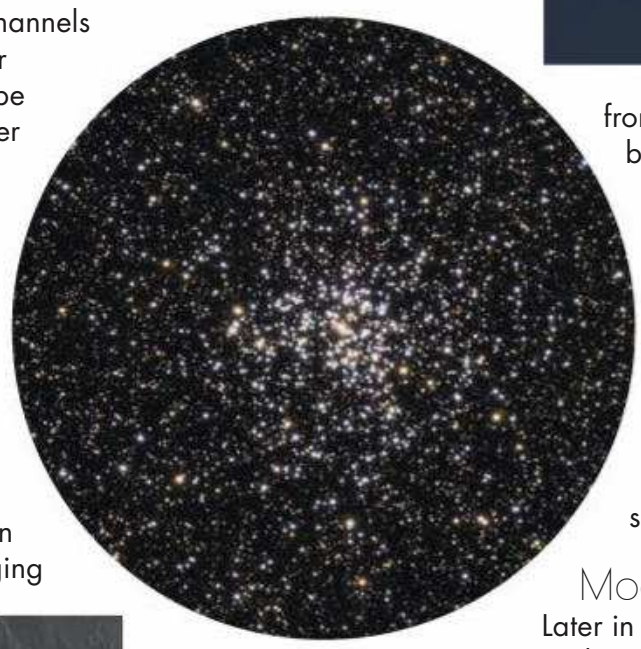
The Hyginus & Triesnecker rille systems

Some of the most interesting lunar features to observe with a telescope are rilles. These are narrow channels or valley-like depressions that traverse the lunar landscape and are thought, in some cases, to be where ancient lava tubes have collapsed. Under the right illumination they appear like thin, dark lines against their brighter grey surroundings. Two of the finest lunar rille systems – those next to the craters Hyginus and Triesnecker – are well lit on the night of 15 November.

The full Moon rising

If you've never used binoculars or a telescope to watch the full Moon slowly rising over the eastern horizon, mark 23 November in your diary. That night look for the Moon emerging from the murk glowing a deep orange, slowly becoming more perfectly silver and round as the effects of our atmosphere wear off with the lunar disc's increasing altitude.

► **Both the inferior planets – Venus (pictured) and Mercury – have phases, just like the Moon's**



▲ **M37 is an open star cluster found in the constellation of Auriga**

The crescent Venus

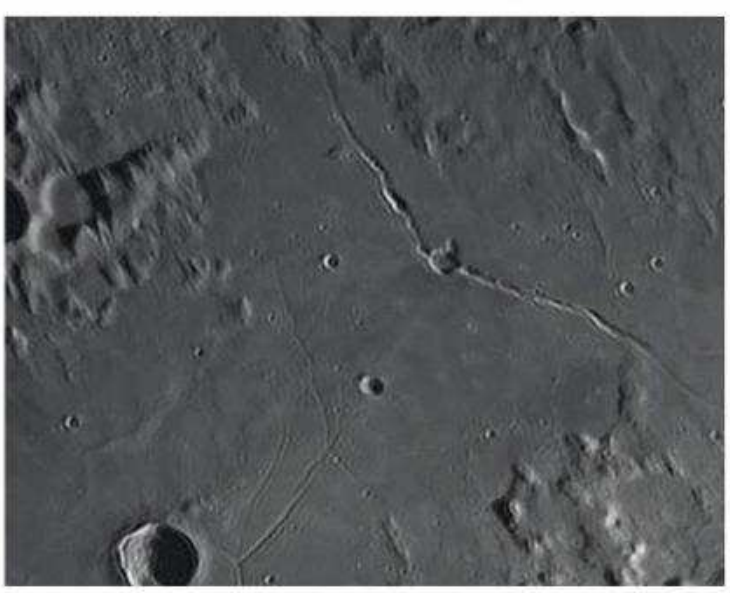
Did you know that the inferior planets, Mercury and Venus, show phases like the Moon does? Later this month, Venus – exhibiting a beautiful crescent shape – becomes well placed in the pre-dawn eastern sky. See the Sky Guide, on page 56, for more.

Moon halo

Later in November – when the Moon is shining bright and sitting high in a dark sky – keep an eye out in the heavens for a ghostly, white ring around our nearest neighbour. This is known as a 22° lunar halo and it's formed when moonlight is refracted by tiny ice crystals suspended within thin – often fairly uniform – clouds drifting overhead.

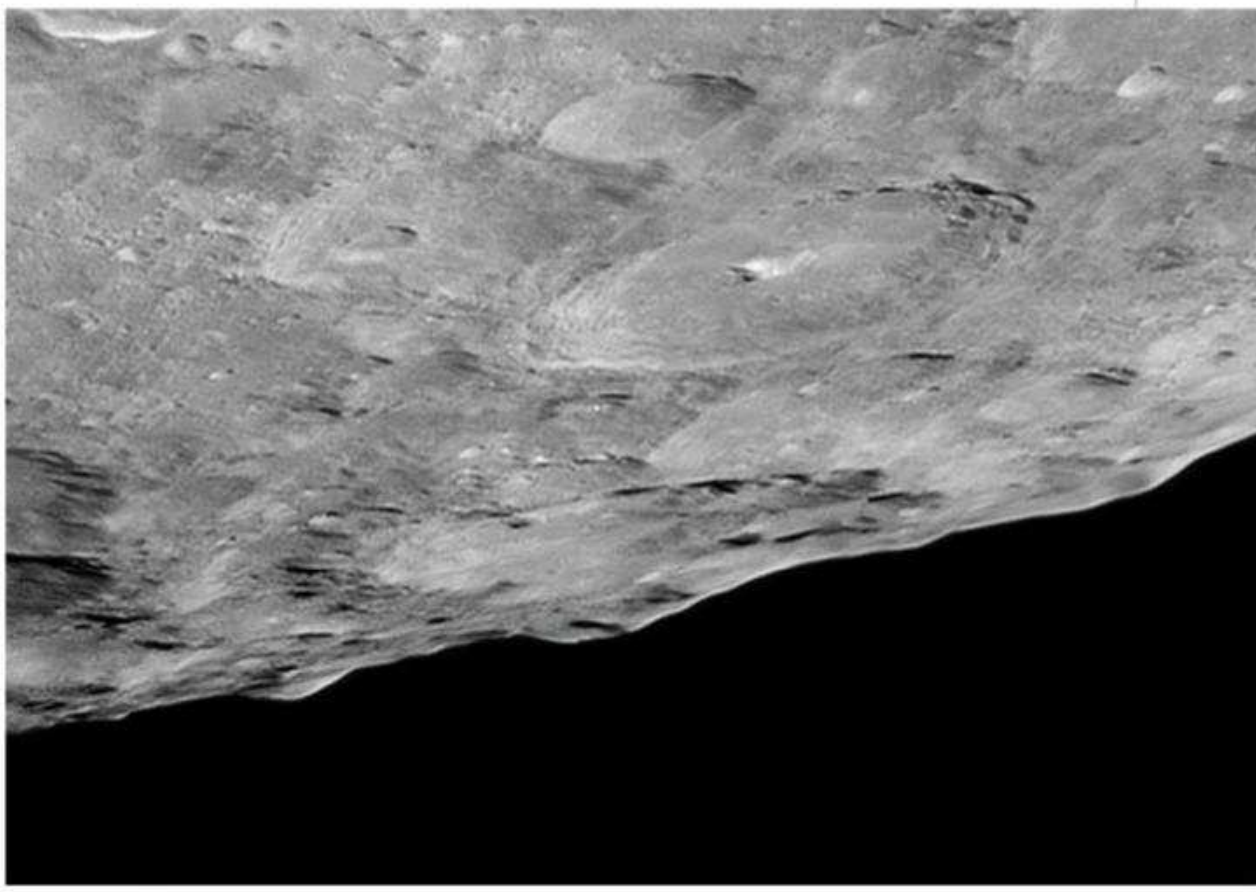
Crater Copernicus

If you aren't having much luck spotting Leonid meteors on the evening of 17 November, turn a telescope towards the Moon where you'll be guaranteed a captivating sight if the skies are clear. That's because on this night the magnificent crater Copernicus – with its complex, terraced walls and central mountains – will be dramatically lit, close to the lunar terminator.



WILL GATER X 6, BERNHARD HUBL/CCDGUIDE.COM

◄ **The Hyginus and Triesnecker rille systems are located a little south of Mare Vaporum**



► The lunar south pole is an incredibly mountainous region with peaks higher than any on Earth

Asteroid Juno

The asteroid 3 Juno is at opposition this month meaning that it's bright enough to be well within reach of a small telescope. To find out more about how to track it down consult the Sky Guide on page 59.

Mountains in the Moon's south polar regions

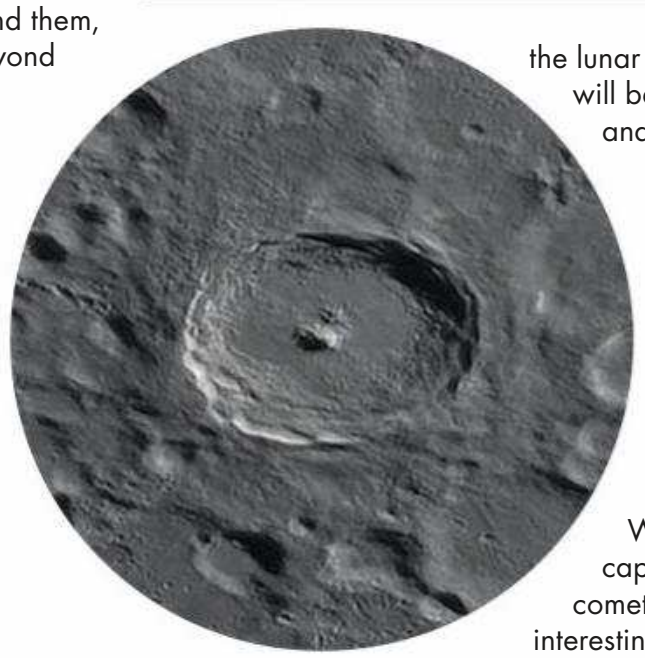
Nothing brings home the rugged three-dimensional nature of our nearest neighbour quite like training a small telescope on it and seeing mountain peaks towering above the limb of the Moon. On the night of 25 November the Moon's tilt is such that some of the more prominent mountains in the lunar south polar region are well positioned for observation. To find them, look along the part of the lunar limb that lies beyond the large crater Moretus.

A moondog

Moondogs, or 'paraselenae', appear as small, elongated wedges of light either side of a bright Moon. They are formed by the same process that creates 2° lunar halos – refraction of moonlight through small ice crystals within thin cloud. Depending on the sky conditions, they can appear individually or in pairs (one on either side of the Moon) and can sometimes be difficult to perceive, so using a camera on a tripod to take an image can confirm their presence.

Interior of Crater Tycho

Tycho is one of the most striking craters on the Moon. Ejecta rays from the impact that formed it stretch right across the lunar disc. But its interior, including a prominent central peak mountain that reaches 2km into the lunar sky, is fascinating to observe as well – it will be ideally illuminated on the nights of 17 and 28 November.



▲ Tycho's central peaks reach to over 1,660m above the crater's floor

Vallis Schröteri

Vallis Schröteri is a lunar rille located within the Oceanus Procellarum. Through a small scope under the right illumination – as it will be on 21 November – its snake-like form is clear to see close to the extremely bright crater Aristarchus.

Comet 46P/Wirtanen

We finish this look at some of this month's most captivating sights for beginners with our first comet. 46P/Wirtanen has the potential to be an interesting binocular object, low down in the south around 10pm, at the end of the month. As it climbs ever higher in the sky through early December it should become easier to spot – the perfect target to segue us from November into the winter observing season!

To the far right is a moondog. Sometimes you'll see another one the same distance away on the other side of the Moon at the same time

10 YEAR ANNIVERSARY

Insight Investment

Astronomy Photographer of the Year

With the world's premier astrophotography competition celebrating its 10th anniversary this year, *BBC Sky at Night Magazine* reveals the winning images of 2018

YOUR BONUS CONTENT

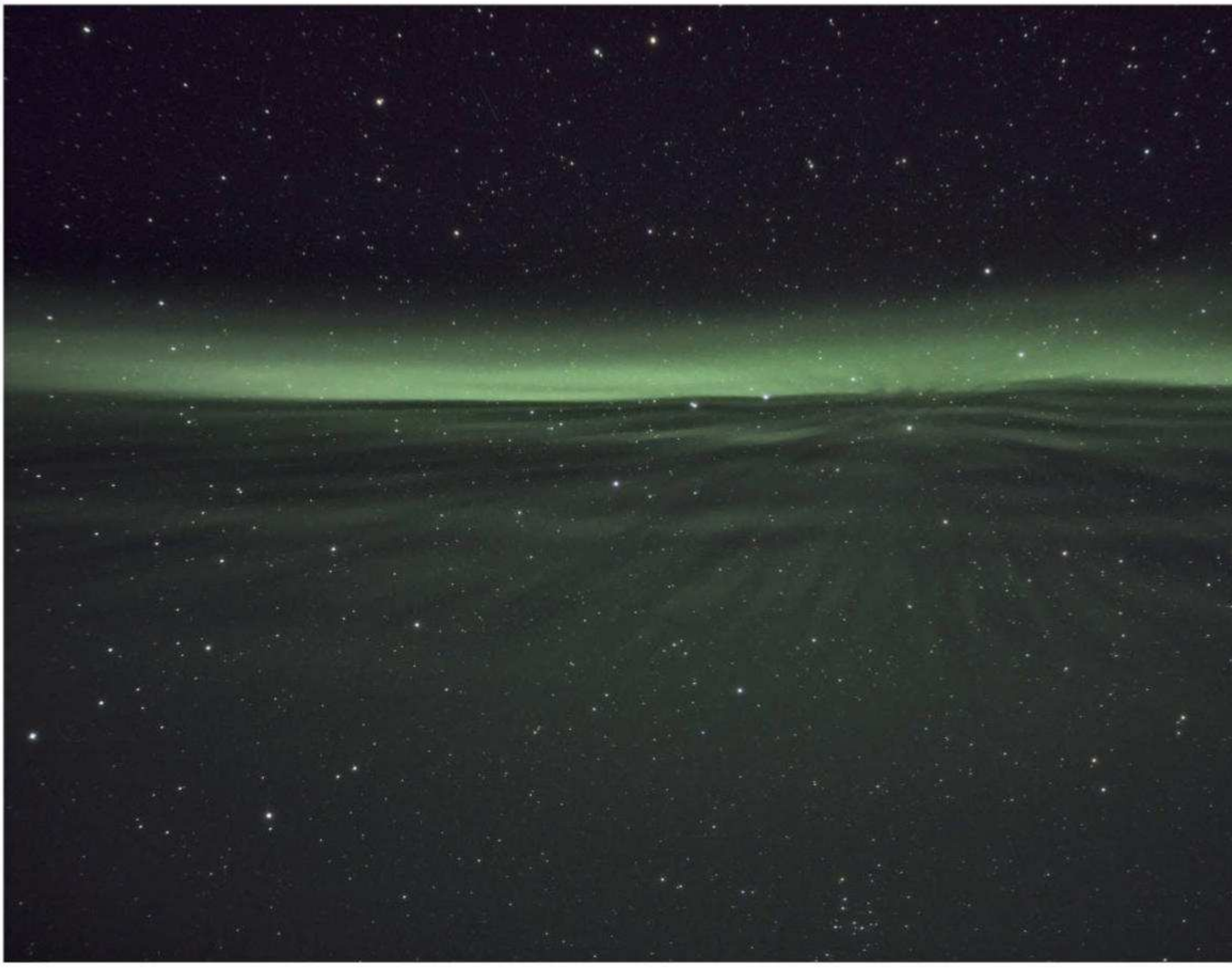
A gallery of the runners up and highly commended entries

This year is a milestone for IIAPY, as it marks a decade since the astro imaging competition began. In that time it has grown from strength to strength and in 2018 the competition welcomed 4,284 entries from 911 photographers around the world, and the Young Astronomy Photographer of the Year category received 186 entries; over twice as many as the previous record. This year's exhibition is being held for the first time at the National Maritime Museum, Greenwich where the 31 top images of 2018 are on display alongside 69 of the best entries from the competition's first decade.

▽ OVERALL WINNER
Category: People and Space

Transport the Soul
Brad Goldpaint (US)
Moab, Utah, US, 20 May 2017
Equipment: Nikon D810 DSLR camera, 14mm f/4 lens
Exposure: ISO 2500, 20″

10 YEAR ANNIVERSARY



△ Category: Planets, Comets and Asteroids

The Grace of Venus

Martin Lewis (UK), St Albans, Hertfordshire, UK, 15 March 2017

Equipment: ZWO ASI174MM camera, home-made 444mm (17.5-inch) Dobsonian, home-made equatorial tracking platform, Astronomik 807nm IR filter, f/28 lens

Exposure: 5.3″

△ Category: Our Moon

Inverted Colours of the Boundary Between Mare Serenitatis and Mare Tranquillitatis

Jordi Delpeix Borrell (Spain), L'Ametlla del Vallès, Barcelona, Spain, 6 December 2017

Equipment: ZWO ASI224MC camera, Celestron EdgeHD 14 Schmidt-Cassegrain, Sky-Watcher NEQ6 Pro mount, 4,200mm f/12 lens

Exposure: Multiple 20ms

◁ Category: Aurorae

Speeding on the Aurora Lane
Nicolas Lefaudeux (France), Sirkka, Finland, 30 March 2017
Equipment: Sony ILCE-7S2 camera, 20mm f/1.4 lens
Exposure: ISO 2000, 3.2″

△ Category: Sir Patrick Moore Prize for Best Newcomer

Galaxy Curtain Call Performance
Tianhong Li (China), Ming'antu, China, 23 September 2017
Equipment: Nikon D810A DSLR camera, 35mm f/2 lens
Exposure: (Sky) ISO 1250, 16x60″; (ground) ISO 640, 4x120″

▽ Category: Robotic Scope

Two Comets with the Pleiades
Damian Peach (UK), Remote Astronomical Society Observatory, Mayhill, New Mexico, US, 19 September 2017
Equipment: SBIG STL11000M CCD camera, Takahashi FSQ-106 ED refractor, Paramount ME mount, 530mm f/5 lens
Exposure: LRGB, 30′ each

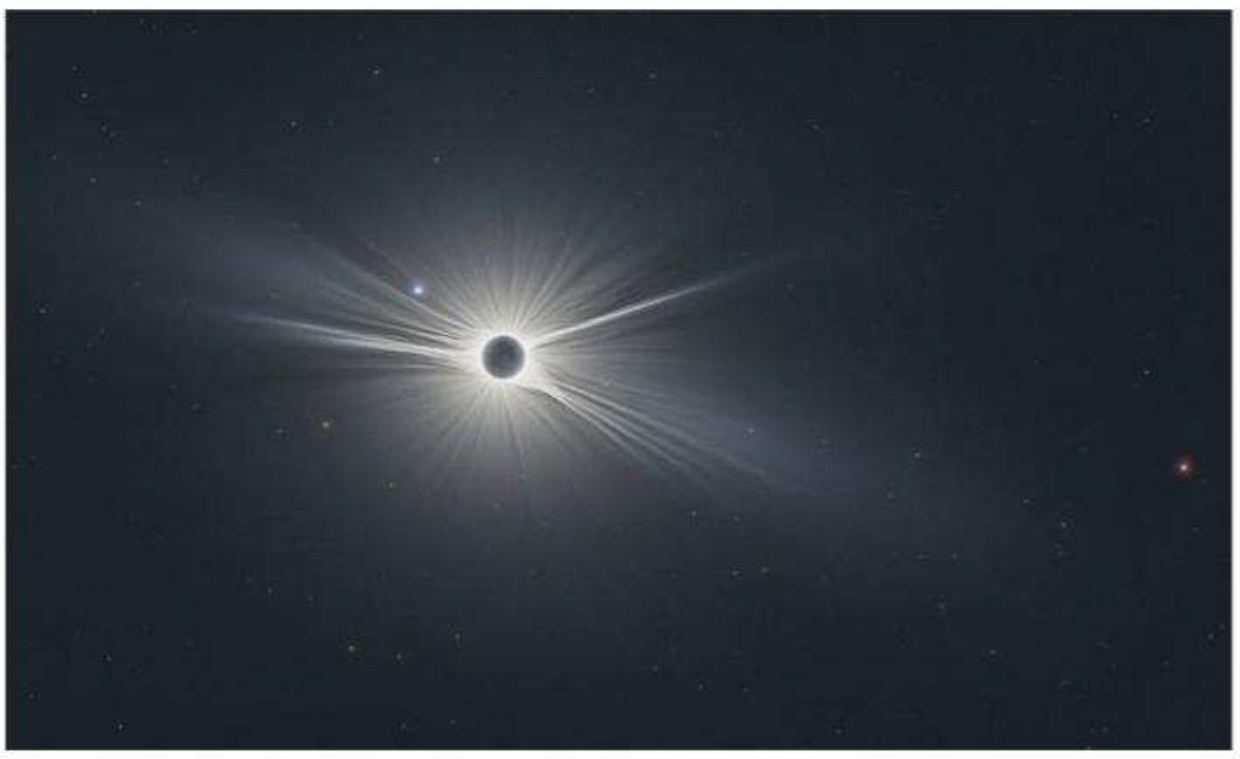
10 YEAR ANNIVERSARY

▽ Category: Young Astronomy Photographer of the Year

Great Autumn Morning
Fabian Dalpiaz (aged 15, Italy), Alpe di Siusi, Dolomites, South Tyrol, Italy, 16 October 2017
Equipment: Canon EOS 5D Mark III DSLR camera, 50mm panorama f/2 lens
Exposure: ISO 6400, 8″

△ Category: Galaxies

NGC 3521, Mysterious Galaxy
Steven Mohr (Australia), Carapooee, Victoria, Australia, 13 February 2018
Equipment: SBIG STXL-11000 CCD camera, PlaneWave CDK 12.5-inch astrograph, Astro-Physics 900GTO mount, Baader 2,541mm f/8 lens
Exposure: 33x20′ luminance, 12x20′ Ha, 450x12-18″ RGB



Category: Our Sun ▷

Sun King, Little King and God of War
Nicolas Lefaudeux (France), Unity, Oregon, US, 21 August 2017
Equipment: Nikon D810 DSLR camera, Nikkor 105mm f/1.4 AF-S ED lens
Exposure: ISO 64, multiple exposures: 0.3″, 0.6″, 1.3″

△ Category: Stars and Nebulae

Corona Australis Dust Complex
Mario Cogo (Italy), Tivoli Southern Sky Guest Farm, Namibia, 18 August 2017
Equipment: Canon EOS 6D cooling CDS modified DSLR camera, Takahashi FSQ-106 ED refractor, Astro-Physics 1200GTO mount, 530mm f/5 lens
Exposure: ISO 1600, 6h

Category: Skyscapes ▷

Circumpolar
Ferenc Szémár (Hungary), Galyatetö, Hungary, 17 February 2018
Equipment: Sony SLT-A99V DSLR camera, Minolta 80-200 135mm f/2.8 lens
Exposure: ISO 640, 50x300″

YOUR BONUS CONTENT

Download extra guides to help keep your kit warm this season

KEEP WARM and carry on

Get ready for the chilly new astronomy season with our guide to beating the cold

ABOUT THE WRITER
Caledonian astrophotographer Stuart McIntyre has survived many cold nights observing in the majestic Scottish Highlands

Astronomy is a tough pursuit to dress for because there tend to be brief amounts of strenuous activity setting up, then hours of standing about. We've all experienced the frustration of having to abandon a potentially amazing night of astronomy because our bodies can take no more battering from the elements.

Planning is key. Wrap yourself in multiple thin layers, as this traps warm air more effectively than one thick jumper. It also means you can peel off a few layers if you get too warm, something you may need to do if you find yourself with a rapid heart rate and feeling weak while sweating – a sign, ironically, of heat exhaustion caused by wrapping up *too* warm. Another issue that can catch you out is wind chill, when the actual ambient temperature is not particulary low but the whipping wind lowers your body warmth.

I personally avoid scarves and balaclavas. I've had many a bad experience with the vapour from my breath condensing on their material, which then causes discomfort as the moisture cools next to your skin. If you have a good hat and down jacket, I find that raising the hood is good enough to keep you warm.

The following is a guide to the kit that should keep you warm on a winter's night, but the best advice is to shop around and see what you can find. Above all keep warm, stay safe and enjoy the longer nights that lie ahead.

WWW.THESECRETSTUDIO.NET X 6, STUART MCINTYRE

1 Hat

Karrimor thermal hat
£7.99 • www.karrimor.com
A thermal hat is a good choice as it will cover your head and ears and keep them warm, but thin enough that you can still pull your hood up. I avoid waterproof materials as I find them uncomfortable when wearing them for longer periods of time.

2 Down jacket ▷

Rab Asylum Jacket
£200 • www.rab.equipment/uk
Down is perfect for stargazing: in terms of warmth for weight, you can't beat it. Go with higher quality fill, as cheap down jackets often contain more feathers, which reduces their ability to trap air, lowering their insulation value. This model is warm and comfortable, with a collar you can zip up to cover your mouth and nose.

3 Windproof jacket

The North Face Apex Flex GTX
£250 • www.thenorthface.co.uk
Make the distinction between windproof and waterproof: if you're standing in the rain you're doing astronomy wrong! You want material that breathes well and is comfortable to wear for longer periods of time. Consider buying one size too big so that it can fit over multiple layers.

4 Gloves

Montane Windjammer Glove
£45 • www.montane.co.uk
It's difficult to strike a balance between keeping your hands warm and being able to hit small buttons on your mount's control pad. The gloves you choose will depend on how much you need to work with the more fiddly aspects of practical astronomy. These ones are designed to prevent wind chill and keep your fingers dextrous.

5 Windproof trousers

Sprayway Men's All Day Rainpant
£80 • www.sprayway.com
Go with softshell, which will be very wind and water resistant and great for keeping you warm. These trousers are breathable and comfortable as they are made from stretchy, flexible material. The inner lining also means they can be quickly pulled on as over-trousers or worn on their own.

6 Boots

Scarpa Delta GTX Activ
£220 • www.scarpa.co.uk
Boots are a very personal thing. A recommendation can only speak to the quality and intended use, but comfort and fit is every bit as important as getting something appropriate for the task at hand. These come with autofit foam inserts in the heel and can be laced up to the ankle for support.

LAYER UP TO STAY WARM

1 Base layer

Icebreaker Everyday Long-Sleeve Crewe
£54.99 • www.ellis-brigham.com
For the base layer, comfort is key as it will be directly touching your skin and can't be conveniently changed in the field. Merino wool is breathable, lightweight and itch-free.

2 Thermal leggings

Icebreaker 200 Oasis Leggings
£64.99 • www.ellis-brigham.com
The function of fabric touching the skin is to wick moisture away. Avoid cotton and stick with Merino wool. Its fibres are thinner than normal wool, making it good for performance and comfort.

3 Mid layer

Rab Nexus Pull-On
£55.00 • www.rab.equipment/uk
The mid layer is your insulation: it keeps you warm. This model is a stretchy fleece material, meaning it will keep in the heat around your body without restricting your movement.

4 Socks

Lorpen T3 Heavy Trekker Socks
£23 • www.lorpen.co.uk
Your feet will be doing most of the work and have a bad habit of sweating. Good quality, thick socks will keep you warm and dry, and are also comfortable in hard-shell footwear.

KEEP THE COLD FROM YOUR CAMERA

Cold weather doesn't just affect your body: your equipment can suffer too

There's not much point being able to stay out in the cold indefinitely if your camera lens converts itself to a frosted glass paperweight.

I have two techniques that will keep my lens at a more ambient temperature. An affordable lightweight option is to use hand warmers attached by hair bands. The reusable ones let their energy out quickly for about 30 minutes, which I find more useful than the slower, disposable types. They struggle in sub-zero conditions, though, so the other method is to electrically heat the lens. I use a small 12V gel battery connected to a 12-24V dimmer switch connected to an astronomical anti-dew band. This works very well, although you have to balance the longer running time of bigger batteries against how much weight you are willing to put up with!


Keep frosted-up lenses at bay for a clear view

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Magic © Jingyi Zhang

The Sky Guide November

As Orion returns to the UK's skies, we take an early look at the objects in and around the mighty Hunter's sword

PETE LAWRENCE

GET THE SKY GUIDE WEEKLY

For weekly updates on what's best to observe, sign up to our email newsletter: **www.skyatnightmagazine.com/iframe/newsletter-signup**

ABOUT THE WRITERS

Pete Lawrence is an astronomer and astro imager, and presents *The Sky at Night* monthly on BBC Four

Stephen Tonkin is a binocular observer. Find his tour of the best sights for both eyes on page 60

RED LIGHT FRIENDLY

To preserve your night vision, this Sky Guide can be read using a red light under dark skies

DON'T MISS...

- ✦ Comet 46P/Wirtanen is predicted to become visible to the naked eye
- ✦ Leonid meteor shower peaks
- ✦ Take a tour around the Moon's Marsh of Epidemics

NOVEMBER **HIGHLIGHTS**

Your guide to the night sky this month

FRIDAY ▶ 2

Early risers will be greeted by the sight of a 33%-lit waning crescent Moon 2° north of the bright mag. +1.3 star Regulus (Alpha (α) Leonis). Look for the pair towards the east from around 01:30 UT. By 03:30 UT the gap between them will have lessened to 1.5°.

SUNDAY 4

Minor planet 3 Juno is currently quite bright, reaching mag. +7.5 today and remaining at this level until the end of the month. Juno is at opposition on 17 November.

TUESDAY 6

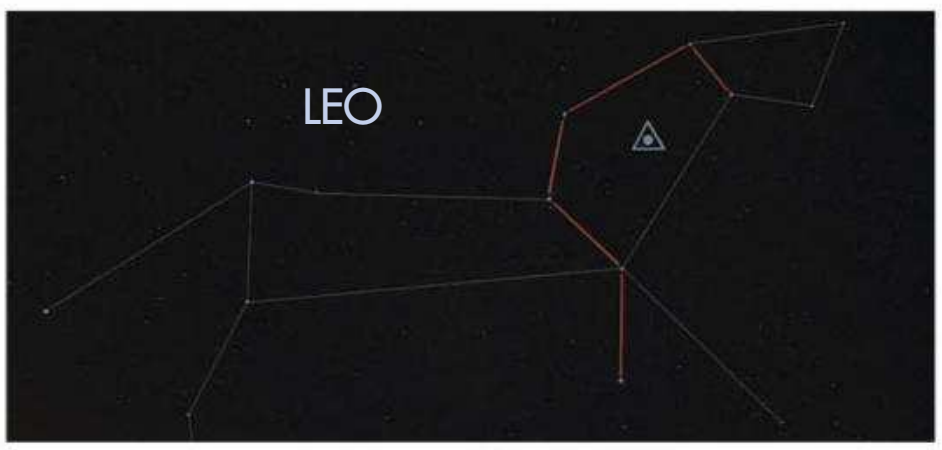
After the Moon's close encounter with Regulus on 2 November, an even thinner lunar crescent, just 2% lit, can be seen 8.3° north of Venus this morning. Look for them after 06:00 UT low in the east-southeast. Mag. +1.0 Spica (Alpha (α) Virginis) sits 3.7° above Venus at this time.

FRIDAY ▶ 9

With the Moon setting relatively early on, an observing session into the early hours will give you opportunity to scrutinise Orion's Sword, the subject of this month's Deep Sky Tour on page 62.

WEDNESDAY 14

The brilliant mag. –4.4 planet Venus can be seen very close to mag. +1.0 Spica at the moment. Catch this photogenic celestial couple at around 06:00 UT, low in the east-southeast. On 14 November the apparent separation is 1.3°.



◀ SATURDAY 17

Tonight is the peak of the annual Leonid meteor shower, best observed after 00:00 UT.

Tonight is a good time to look for Palus Epidemiarum on the Moon – the subject of this month's Moonwatch feature on page 58.

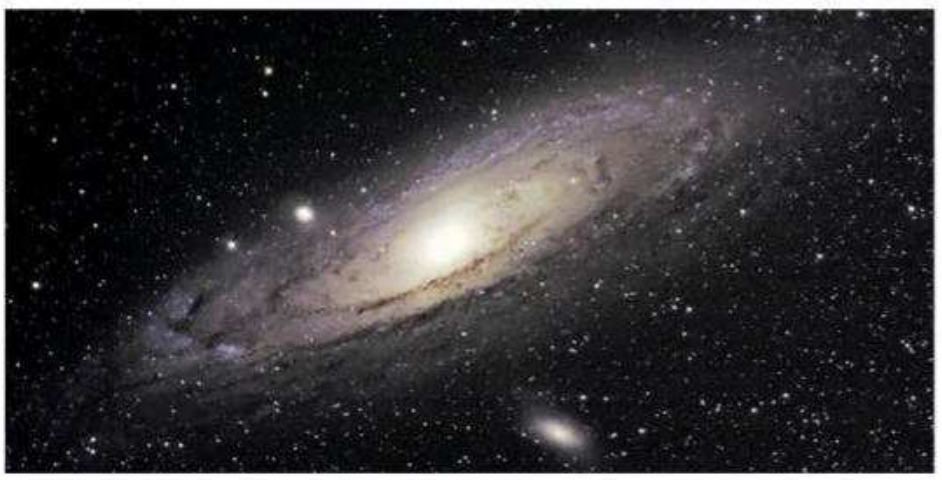
SUNDAY 18

In theory at least, comet 46P/Wirtanen becomes a naked-eye object this evening. A bright, waxing gibbous Moon and the comet's low altitude mean it's unlikely to be seen at present, but the good news is that it's brightening as it moves north out of Fornax.

TUESDAY ▶ 27

A late moonrise means there's plenty of opportunity to view the wondrous Andromeda Galaxy, M31, in the early part of the evening. The furthest object visible to the naked eye under normal dark sky conditions, M31 is a popular photographic target.

PETE LAWRENCE X 8



THURSDAY 29

The variable star Mira (Omicron (ο) Ceti) is nearing its peak brightness. Typically, Mira varies between mag. +3.4 and mag +9.3.

WEDNESDAY 7

9th magnitude comet 38P/Stephan-Oterma is approaching the 10th magnitude Eskimo Nebula, NGC 2392. The closest approach will be on the nights of 8/9 and 9/10 November with the comet approximately 1° to the west-southwest on 7 November.

THURSDAY ▶ 8

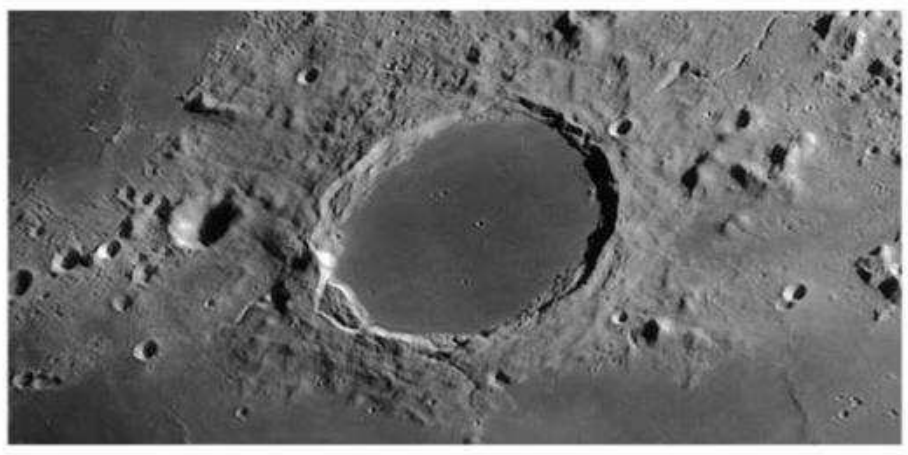
A 1%-lit waxing crescent Moon can be seen 3.2° north of mag. –1.6 Jupiter this evening. Look low in the southwest approximately 20 minutes after sunset. Both will be challenging to spot. Mag. –0.1 Mercury will also be present, 10° left of Jupiter.

SUNDAY ▶ 11

As the sky darkens, find the 16%-lit waxing crescent Moon low in the south-southwest. Look below and slightly right of the Moon to locate Saturn at mag. +1.0. The planet and Moon appear 45 arcminutes apart (measured from the Moon's centre) at 17:00 UT.

MONDAY 12

The Northern Taurid meteor shower is at its peak with a low zenithal hourly rate (ZHR) of five meteors per hour. It's important to stress that the peak period is broad, possibly as long as 10 days. The waxing crescent Moon is ideally placed for a good view of the shower.



◀ FRIDAY 16

The Moon's phase is now sufficiently large to reveal crater Plato for telescopic viewing. This month's challenge on page 61 is to see how many tiny craterlets you can see on its apparently smooth lava floor.

TUESDAY ▶ 20

It is worth getting up early for a telescopic view of Venus in November as the planet is currently in a slender, crescent phase. On 20 November it rises three hours before the Sun and shows a 15%-lit crescent, 48 arcseconds across.

FRIDAY 23

Look about 1° south of the full Moon to find mag. +0.8 Aldebaran (Alpha (α) Tauri). A real photographic challenge is whether you can capture the Moon with the rest of the Hyades open cluster, through which it is currently passing.

FRIDAY 30

As we leave November, comet 46P/Wirtanen is gearing up for its rapid sprint northward. Predicted to be mag. +4.9 this evening, the comet – currently located just outside southern Cetus – is expected to reach mag. +3.8 by the middle of December.

FAMILY STARGAZING – ALL MONTH

The Pleiades open cluster is nicely on view during November evenings in the eastern part of the sky from 19:00 UT onwards, easily observable with the naked eye. An alternative name for the Pleiades is the Seven Sisters and it's an interesting and easy-to-do exercise to get youngsters to count how many stars they can see. Although 'Seven' Sisters may seem to give the game away, keen, young eyes should be able to pick out more than seven. Try repeating the exercise under different sky conditions to see if scores can be improved.

www.bbc.co.uk/cbeebies/shows/stargazing

NEED TO KNOW

The terms and symbols used in *The Sky Guide*

UNIVERSAL TIME (UT) AND BRITISH SUMMER TIME (BST)
Universal Time (UT) is the standard time used by astronomers around the world. British Summer Time (BST) is one hour ahead of UT.

RA (RIGHT ASCENSION) AND DEC. (DECLINATION)
These coordinates are the night sky's equivalent of longitude and latitude, describing where an object is on the celestial 'globe'.

FAMILY FRIENDLY
Objects marked with this icon are perfect for showing to children

NAKED EYE
Allow 20 minutes for your eyes to become dark-adapted

PHOTO OPPORTUNITY
Use a CCD, planetary camera or standard DSLR

BINOCULARS
10x50 recommended

SMALL/ MEDIUM SCOPE
Reflector/SCT under 6 inches, refractor under 4 inches

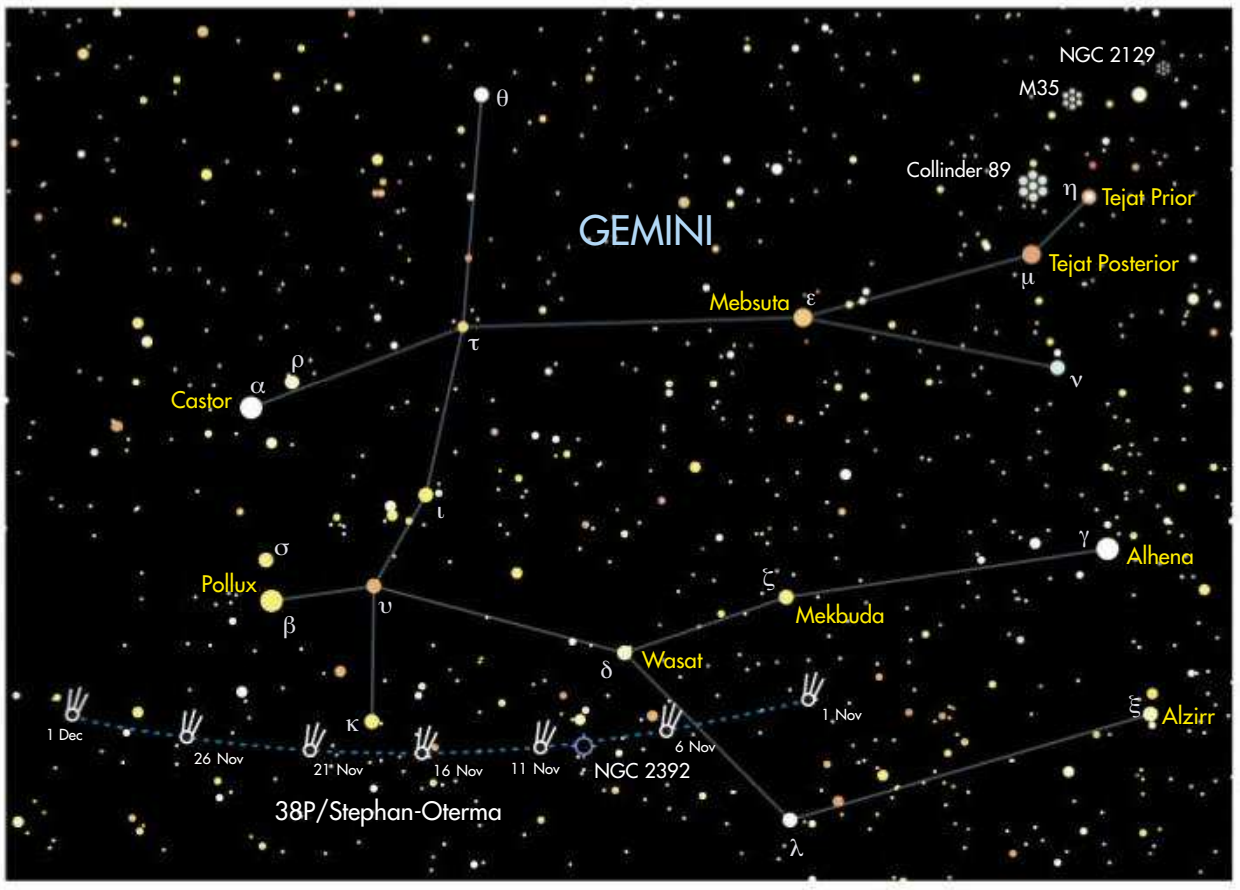
LARGE SCOPE
Reflector/SCT over 6 inches, refractor over 4 inches

GETTING STARTED IN ASTRONOMY

If you're new to astronomy, you'll find two essential reads on our website. Visit http://bit.ly/10_Lessons for our 10-step guide to getting started and http://bit.ly/First_Tel for advice on choosing a scope.

THE BIG **THREE**

The three top sights to observe or image this month



▲ **38P/Stephan-Oterma might be a dim comet but it's well placed for UK viewing in November**

DON'T **MISS**

November comets

WHEN: 1-15 and 28-30 November

There are two reasonably bright comets on view this month: 38P/Stephan-Oterma and 46P/Wirtanen. Of the two, Wirtanen is brighter but also the least well positioned, for the time being at least. Slowly leaving the confines of the southern constellation of Fornax, the Furnace, and slipping across the border into Cetus, the Whale, comet 46P/Wirtanen is predicted to brighten past the naked eye threshold around 8 November. As it goes it'll pick up pace, tracking north across the night sky. It will be well positioned for northern hemisphere viewing during December. Consequently, any views of 46P/Wirtanen you manage to get during November can be considered good training for next month's bright dash across the heavens. At its peak, 46P/Wirtanen is predicted to reach mag. +3.8.

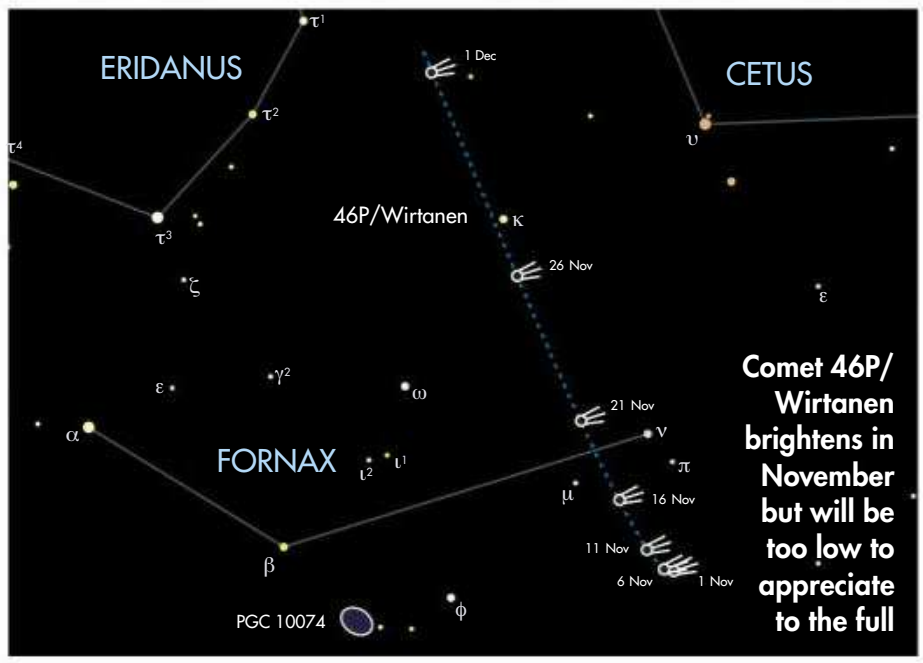
The low declination of Fornax will make locating 46P tricky this month. Also, although the comet is brightening, the Moon will cause problems, its glare creating a very efficient filter to block out the diffuse comet. However, the Moon will slip out of the way right at the end of November and it should be possible to spot 46P/Wirtanen on the starting blocks ready for its race north.

If you find the low altitude of 46P/Wirtanen challenging, 38P/Stephan-Oterma should prove less of a problem. Admittedly this comet is notably dimmer, starting the month off at mag. +9.4 and brightening to just +9.2 by 11 November, a value it holds for the rest of the month. But this comet is really well located for UK viewing, tracking to the east of the outline figure of the twin Pollux in the constellation of Gemini, the Twins.

At this level of brightness, 38P is best suited for telescope viewing with a low-power eyepiece. However, depending on the concentration of the comet's head, increased magnification is always worth a try – just use small magnification jumps.

The comet crosses the midpoint of the imaginary line between mag. +3.5 Wasat (Delta (δ) Geminorum) and mag. +3.6 Lambda (λ) Geminorum at 00:00 UT on 5 November. It then continues to track northeast passing very close to the Eskimo Nebula, NGC 2392, during the nights of 8/9 and 9/10 November. It's closest to the planetary nebula during the morning of 9 November. This is a great opportunity if you're into astrophotography, the Eskimo being ranked as a mag. +10.1 object not too dissimilar to the comet. 38P/Stephan-Oterma also lies close to mag. +3.6 Kappa (κ) Geminorum on the night of 17/18 November.

The comet was last at perihelion on 26 August of this year and geometrically will be at its closest to Earth in January of next year when current predictions have it as a 10th magnitude object fading to 11th.

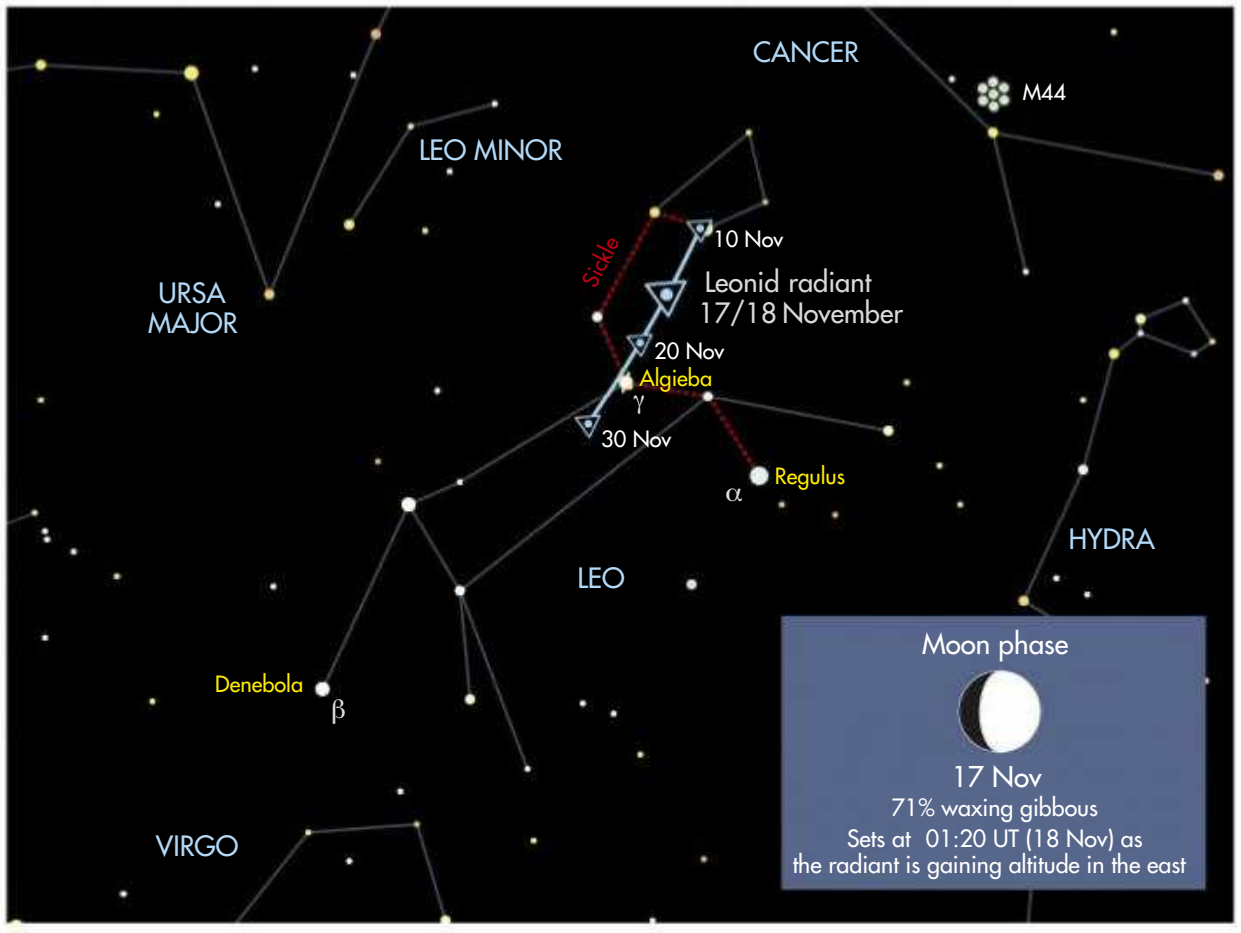


Comet 46P/Wirtanen brightens in November but will be too low to appreciate to the full

PETE LAWRENCE X 4

November meteors

WHEN: 6/7 and 16/17 November (Taurids); 16/17 and 18/19 November (Leonids)



▲ **The radiant for the Leonid meteor shower travels through Leo's Sickle asterism during November**

November is the month in which the annual Leonid meteor shower reaches its peak but before this happens, there's much less understated activity from the Northern Taurid stream. This is active from 20 October to 10 December, with peak activity occurring on 12 November. Although the shower has a low peak zenithal hourly rate (ZHR) of just five meteors per hour, it has a broad peak period, possibly as wide as 10 days. The 27km/s entry speed of the Taurids is slow in meteor terms and this, coupled with some good bright trails, make the shower ideal for general meteor photography.

Where the Taurids are slow the Leonids are very fast, with an entry speed of 71km/s. Every 33 years (the length of the Leonids' parent comet's orbit around the Sun) the shower becomes a storm. This year we're roughly midway between outbursts, the last occurring at the turn of the century, so the general level of Leonid activity will be quite low with an expected ZHR between 10-20 meteors per hour.

Activity normally occurs between 6-30 November with the peak on the night of 17/18 November. The Leonids' radiant drifts slowly over time but on maximum night it's conveniently positioned within the head of Leo, the Lion, in the curved top of the Sickle asterism. A number of low-rate enhancements have been predicted for the days after the peak so it's always worth keeping an eye out.

The Moon is new on 7 November, which is ideal for the Northern Taurids. It's approaching full Moon for the Leonids' peak, but this shower is best observed after local midnight anyway, when the Moon has set, so prospects for a decent display this year are good if the weather plays ball. As ever, give yourself at least 20 minutes in complete darkness before starting your session. Look two thirds of the way up the sky in any direction.

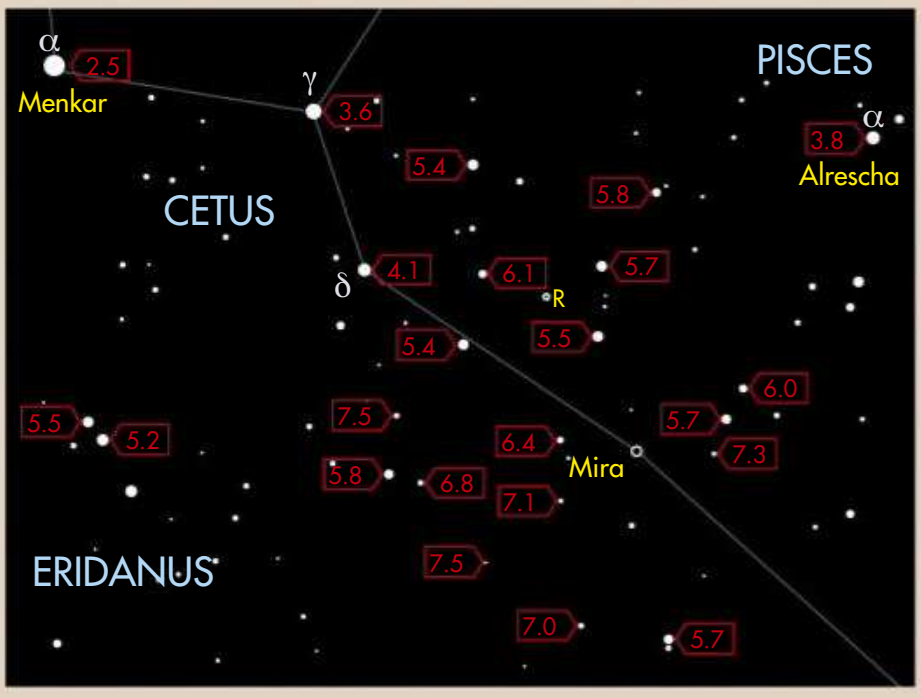
Mira at maximum

WHEN: Last week of November

The constellation of Cetus represents a Whale or Sea Monster in mythology. It's a large, sprawling collection of stars defined by mag. +2.0 Deneb Kaitos (Beta (β) Ceti) to the west and the irregular pentagonal pattern forming the creature's head to the east. Mag. +2.5 orange Menkar (Alpha (α) Ceti) is one of the stars in the pentagon.

The bottom of the head is marked by mag. +3.5 Kaffaljidhma (Gamma (γ) Ceti) which together with mag. +4.1 Delta (δ) Ceti form the neck. A line from Delta to mag. +3.7 Baten Kaitos (Zeta (ζ) Ceti) defines the creature's back. The variable star Mira (Omicron (ο) Ceti) sometimes appears along the back. Also known as 'Wonderful', Mira holds the record for having the largest brightness range of any variable star visible to the naked eye at peak.

From late November into December, Mira should be visible to the naked eye as a tangible addition to Cetus. A typical maximum has it as bright as mag. +3.5. Records exist of it as bright as mag. +2.0, rivalling the brightest star in Cetus. Over a period of 332 days it drops from its easy naked-eye maximum to around 9th magnitude at minimum. At such times, you'll need a telescope to see the star clearly.



▲ **For naked-eye observers, Mira is only part of Cetus some of the time**

THE NORTHERN HEMISPHERE IN NOVEMBER

KEY TO STAR CHARTS

Arcturus — STAR NAME

PERSEUS — CONSTELLATION NAME

GALAXY

OPEN CLUSTER

GLOBULAR CLUSTER

PLANETARY NEBULA

DIFFUSE NEBULOSITY

DOUBLE STAR

VARIABLE STAR

THE MOON, SHOWING PHASE

COMET TRACK

ASTEROID TRACK

STAR-HOPPING PATH

METEOR RADIANT

Circlet — ASTERISM

PLANET

QUASAR

STAR BRIGHTNESS:

MAG. 0 & BRIGHTER

MAG. +1

MAG. +2

MAG. +3

MAG. +4 & FAINTER

5° N E W S — COMPASS AND FIELD OF VIEW

MILKY WAY

WHEN TO USE THIS CHART

1 NOVEMBER AT 00:00 UT
15 NOVEMBER AT 23:00 UT
30 NOVEMBER AT 22:00 UT

On other dates, stars will be in slightly different positions because of Earth's orbital motion. Stars that cross the sky will set in the west four minutes earlier each night.

HOW TO USE THIS CHART

1. **HOLD THE CHART** so the direction you're facing is at the bottom.
2. **THE LOWER HALF** of the chart shows the sky ahead of you.
3. **THE CENTRE OF THE CHART** is the point directly over your head.

SUNRISE/SUNSET IN NOVEMBER*

DATE	SUNRISE	SUNSET
1 Nov 2018	07:09 UT	16:38 UT
11 Nov 2018	07:28 UT	16:20 UT
21 Nov 2018	07:46 UT	16:05 UT
01 Dec 2018	08:03 UT	15:55 UT

MOONRISE IN NOVEMBER*

MOONRISE TIMES

01 Nov 2018, ––:–– UT	17 Nov 2018, 14:30 UT
05 Nov 2018, 04:02 UT	21 Nov 2018, 15:48 UT
09 Nov 2018, 09:05 UT	25 Nov 2018, 18:15 UT
13 Nov 2018, 12:43 UT	29 Nov 2018, 23:10 UT

***Times correct for the centre of the UK**

LUNAR PHASES IN NOVEMBER

MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY
			1	2	3	4
5	6	7 NEW MOON	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23 FULL MOON	24	25
26	27	28	29	30		

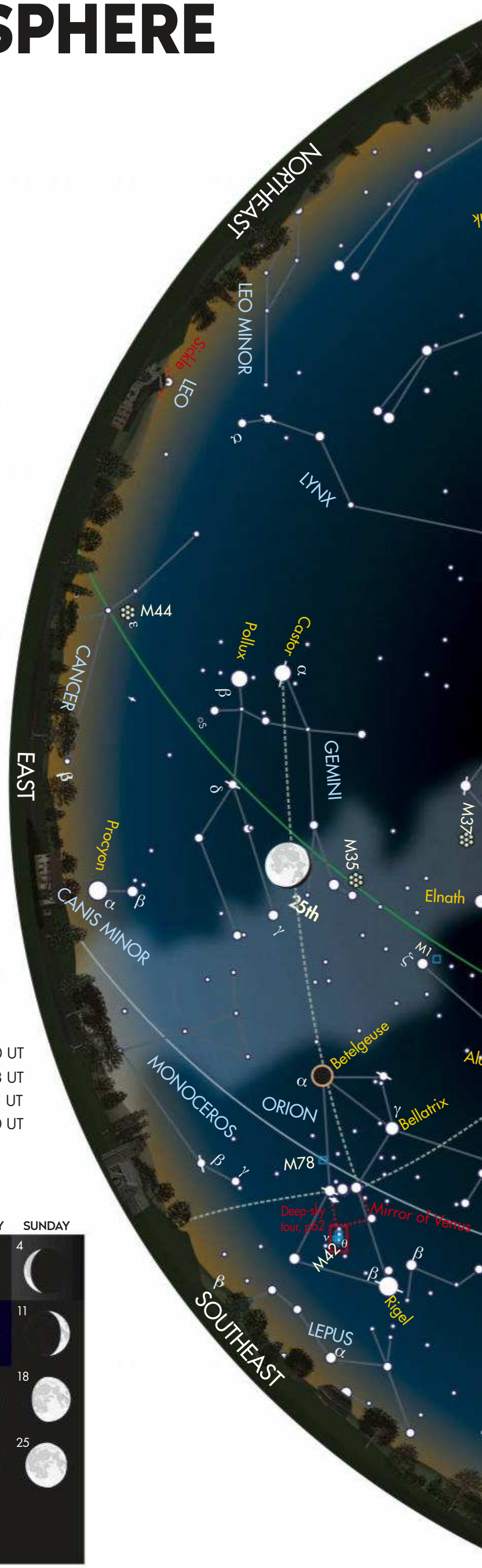


CHART: PETE LAWRENCE

YOUR BONUS CONTENT Paul and Pete's Virtual Planetarium

THE **PLANETS**

PICK OF THE **MONTH**

Venus

Best time to see: 30 November, 06:00 UT
Altitude: 14°
Location: Virgo
Direction: Southeast
Features: Phase, indistinct shadings on the illuminated disc
Equipment: 3-inch or larger telescope

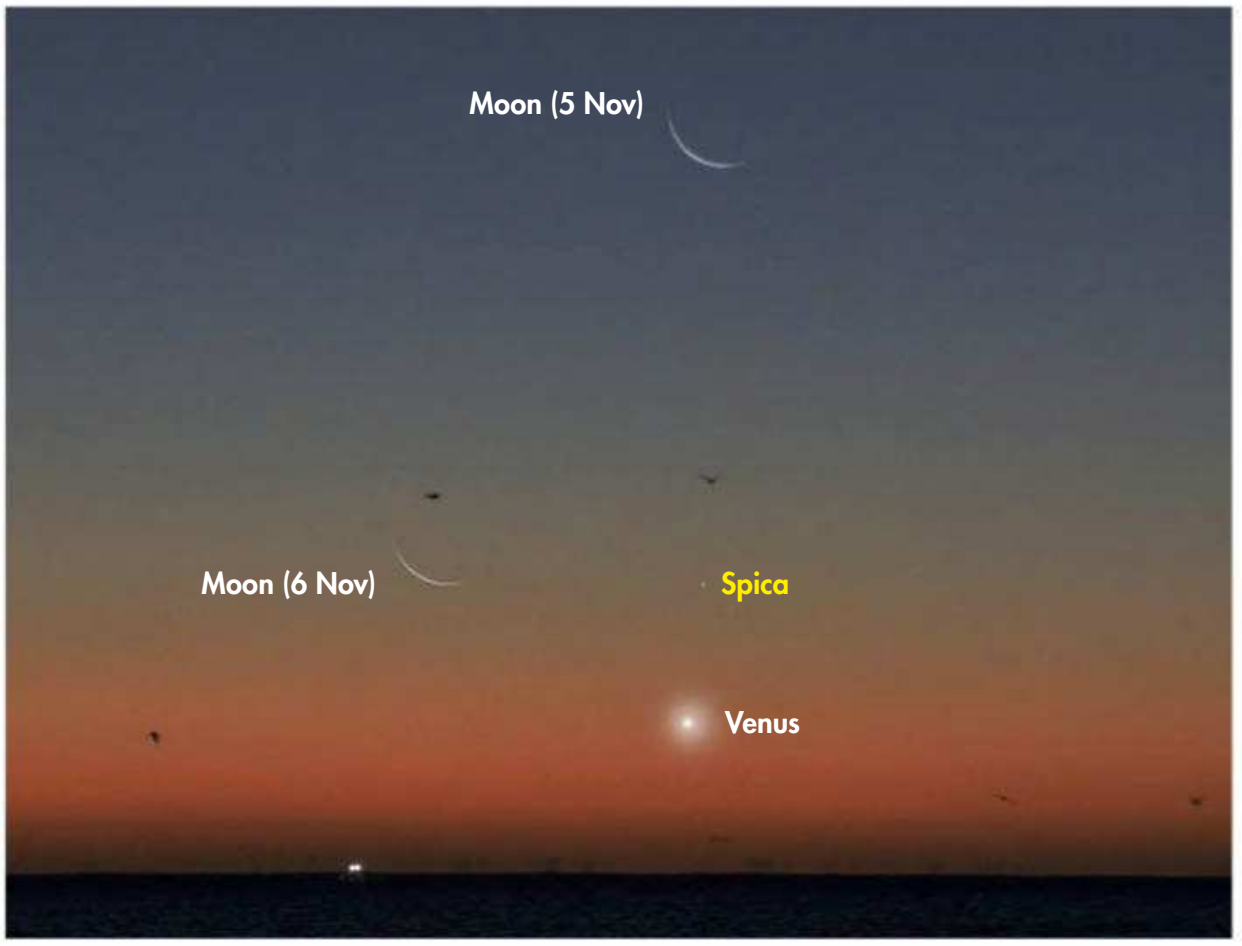
A poor evening showing during late summer and early autumn 2018 meant that the thin crescent of Venus was lost unless you were prepared to hunt for the planet in daylight. However, as it is currently emerging back into the morning sky, brilliant Venus is rapidly gaining height before sunrise, giving you a second chance to see its crescent phase.

Inferior conjunction, when Venus lined up with the Sun on the Earthward part of its orbit, occurred last month, on 26 October. Moving around this close part of its orbit, our view of Venus can change quite rapidly.

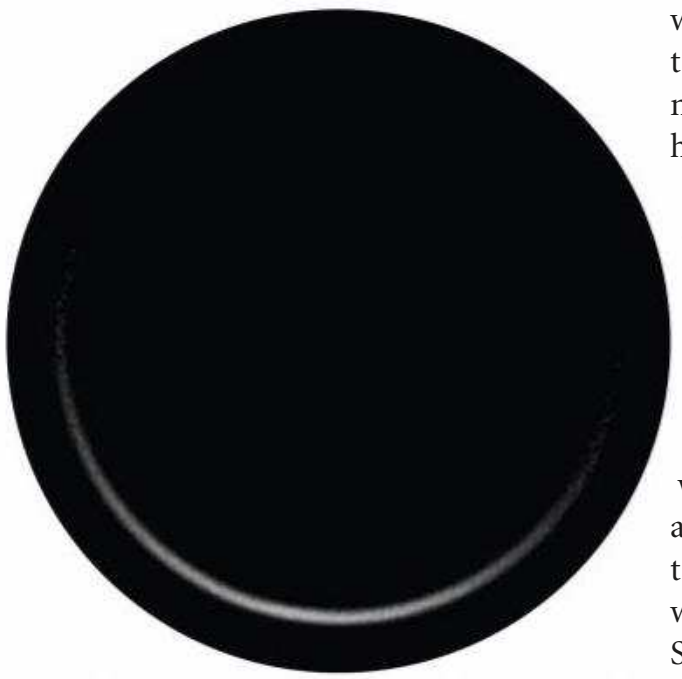
For example, on 1 November the planet shows a 1 arcminute diameter crescent just 1% lit. This rises 30 minutes before the Sun. Compare this to the view one week later, on 8 November when, through a telescope, Venus will appear 57 arcseconds across with a 5% phase. On this date mag. –4.3 Venus rises 100 minutes before the Sun.

By the end of the month Venus's phase will have increased to 25%, and the disc will appear 41 arcseconds across. At this time Venus will shine at an impressive mag. –4.5 and rise just short of four hours before the Sun.

The planet has a couple of notable apparent close encounters with other objects this month. On 5 November, a 6%-lit waning lunar crescent sits 17° above Venus as the planet rises around 06:15 UT (central UK). On the following morning the now 2%-lit waning lunar crescent is located 8° above and left of Venus. Another encounter, this time with a star, happens mid-month when Venus passes close to mag. +1.0 Spica (Alpha (α) Virginis). The best dates to see this will be between 13-15 November, when Venus will appear just 1.2° from the star.



▲ **Venus is joined by a slender, crescent Moon on the mornings of 5 and 6 November. The Moon's appearance in this image has been exaggerated for the sake of clarity**

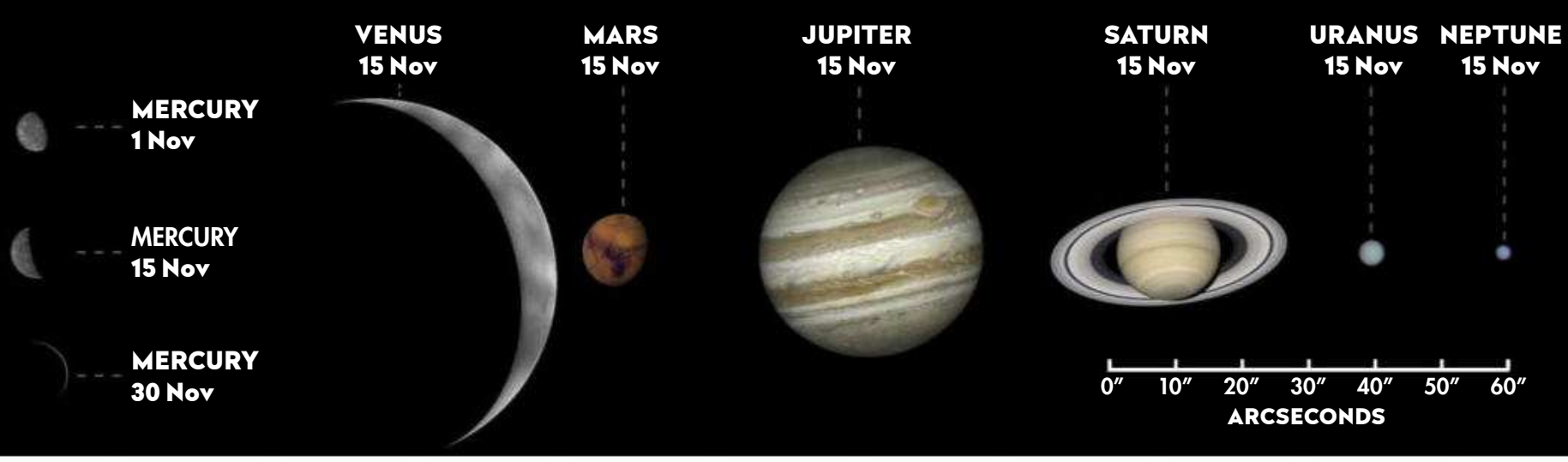


▲ **Venus showing a 1.2%-lit crescent on 12 August 2015 – similar to how it should appear at the start of November**

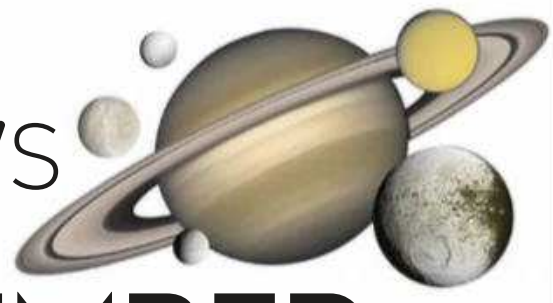
PETE LAWRENCE X 3

THE PLANETS IN NOVEMBER

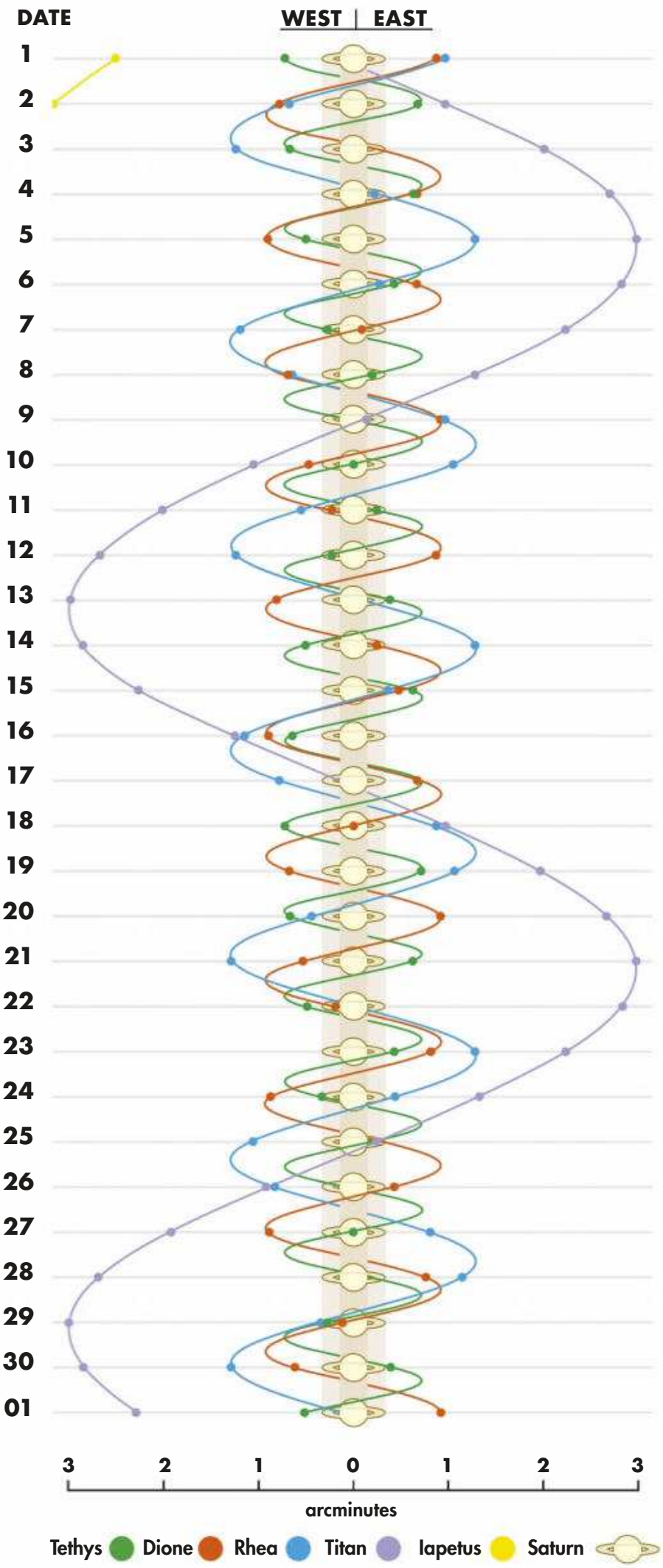
The phase and relative sizes of the planets this month. Each planet is shown with south at the top, to show its orientation through a telescope



SATURN'S MOONS NOVEMBER



Using a small scope you'll be able to spot Saturn's biggest moons. Their positions change dramatically during the month, as shown on the diagram. The line by each date represents 00:00 UT.



Mercury

Mercury is an evening object and despite reaching greatest eastern elongation on 6 November, is unlikely to be seen post sunset as it hardly has any altitude. Inferior conjunction takes place on 27 November after which time the planet is a morning object too close to the Sun to be seen properly in the morning sky.

Mars

Best time to see:
30 November, 06:20 UT
Altitude: 28°
Location: Aquarius
Direction: South

During the first week of November Mars can be seen moving slightly north of the line from Gamma (γ) to Delta (δ) Capricorni. On the evening of 1 November it shines at mag. –0.6 and shows an apparent diameter of 11 arcseconds through a telescope. On 11 November, Mars slips across the border from Capricornus and into Aquarius. It passes very close to the mag. +4.3 star Iota (ι) Aquarii on the evening of 13 November, appearing just 22 arcminutes from the star as they set around 23:15 UT. The first quarter Moon sits nearby on the evening of 15 November. By 30 November, Mars will have dimmed to mag. +0.0 and appear just 9 arcseconds across when viewed through a telescope. On the plus side, the planet now reaches an altitude of 28° when due south as seen from the centre of the UK.

Jupiter

Poorly positioned and unlikely to be seen. Solar conjunction occurs on 26 November.

Saturn

Best time to see:
1 November, 19:50 UT
Altitude: 11°
Location: Sagittarius
Direction: South-southwest

Saturn now appears low in the southwest as darkness falls. The mag. +1.0 planet appears just 46 arcminutes from the centre of a lovely crescent Moon on 11 November, around 17:00 UT when the evening sky is still bright. As darkness descends, the separation will increase slightly. By the end of the month, the planet will be close to the southwest horizon as the sky darkens.

Uranus

Best time to see:
1 November, 23:20 UT
Altitude: 48°
Location: Aries
Direction: South

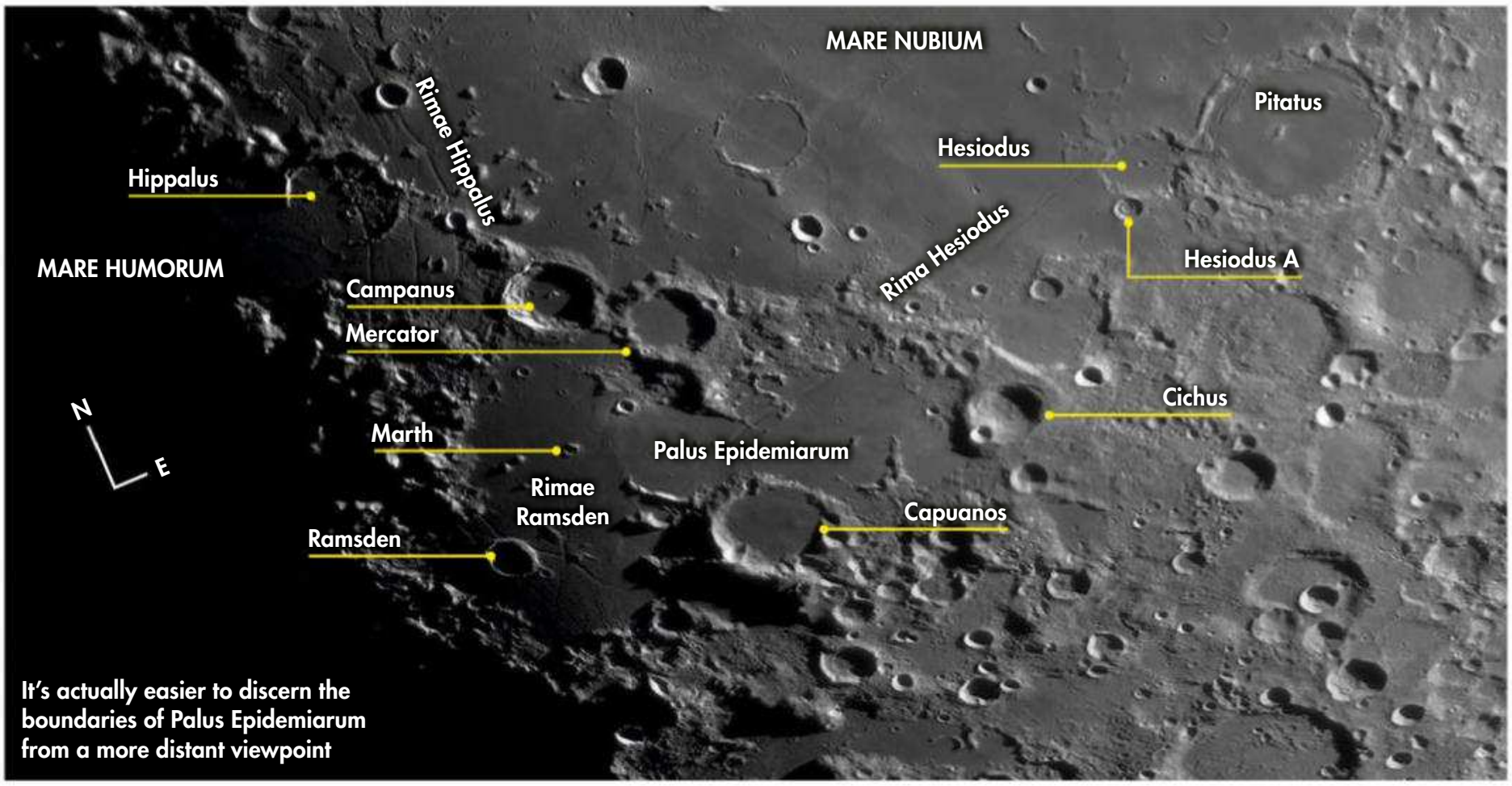
Having just passed opposition on 24 October, the viewing circumstances for Uranus remain excellent in November. At mag. +5.7 it may just be possible to glimpse it with the naked eye under dark sky conditions, but binoculars or a telescope are a surefire way to get a view. Through a telescope, Uranus appears distinctly green. The planet currently resides in Aries, the Ram, but is very close to the border with Pisces where it has appeared for the last few years and into which it will temporarily slip back next month. On 30 November, it sits on the border between the two constellations.

Neptune

Best time to see:
1 November, 20:30 UT
Altitude: 30°
Location: Aquarius
Direction: South

Neptune remains well placed throughout November, close to the mag. +3.7 star Lambda (λ) Aquarii. Though it's at mag. +7.9 you'll need at least a pair of binoculars to see the planet. Mars appears to approach Neptune this month, lying west of Lambda Aquarii at the month's end. Neptune reaches its highest point in the sky, due south, in darkness all month long, although it only just manages this as darkness falls by 30 November.

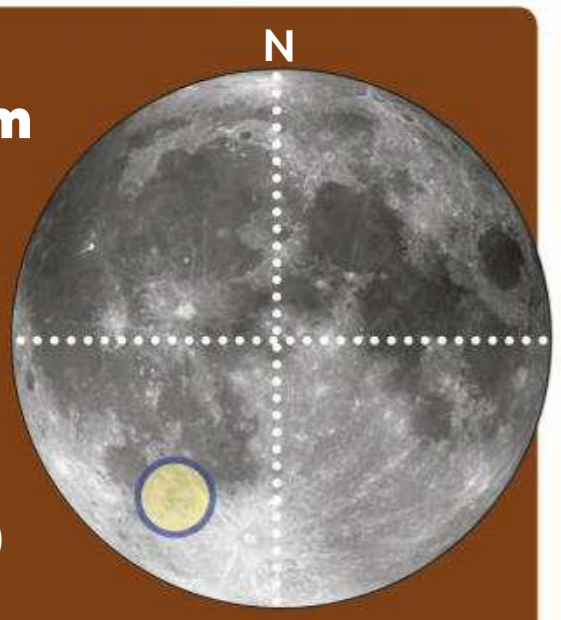
YOUR BONUS CONTENT Planetary observing forms



MOON**WATCH**

Palus Epidemiarum

Type: Lunar marsh
Diameter: 286km
Longitude/latitude: 28.2° west, 32° south
Age: Between 3.2-3.9 billion years
Best time to see: Two days after first quarter (17-18 Nov) and one day after last quarter (2 Nov and 1-2 Dec)
Minimum equipment: 10x binoculars



PETE LAWRENCE X 3

"Hesiodus A is remarkable because it's a double-concentric crater with both an inner and outer rim"

There are a number of Moon features with macabre names. The Lake of Death (Lacus Mortis) and the Marsh of Decay (Palus Putredinis) spring to mind, not to mention this month's Moonwatch target, the **Marsh of Epidemics** (Palus Epidemiarum).

It lies in the southern gap between the touching maria, **Humorum** and **Nubium**. Its dark lava stands out well against the highland region to the south and although it has irregular boundaries, with a bit of imagination you can visualise a rough, east-west elongated diamond shape.

Its most notable feature is the lava-flooded form of 60km **Capuanus** along the southern edge. This crater juts into Epidemiarum, appearing to stretch northwest towards the marsh's centre. The effect is enhanced by extensions to the western and northwestern ramparts of Capuanus, which give the impression that the crater is evaporating into the marsh material. Impressive lunar domes can be found on the floor of Capuanus, best seen when the lighting is oblique.

Opposite Capuanus, situated on the northern border of the marsh are the twin-like craters **Campanus** and **Mercator**, both 48km. The similarity between these craters is quite striking. They are close enough that their outer ramparts join to form a narrow valley that links Palus Epidemiarum to Mare Nubium. Look out for the impressive concentric grooves of **Rimae Hippalus** to the west and northwest of Campanus. These are associated with Mare Humorum and run parallel to its eastern border.

The western part of the marsh is dominated by the flooded 25km crater **Ramsden**. This is associated with its own set of crevasses known as **Rimae Ramsden**. The most obvious section of Rimae Ramsden appears to the north of Ramsden itself, where two sections can be seen running in parallel. Further cracks may be seen between Ramsden and Capuanus. As ever, viewing when the terminator is near is the best strategy as this will emphasise any irregularities in the floor of the marsh.

The eastern border of Palus Epidemiarum is complicated. It's marked by the 41km crater **Cichus**. The residual material littering Epidemiarum's floor between Cichus and Capuanus hints at two heavily eroded and unnamed ghost craters.

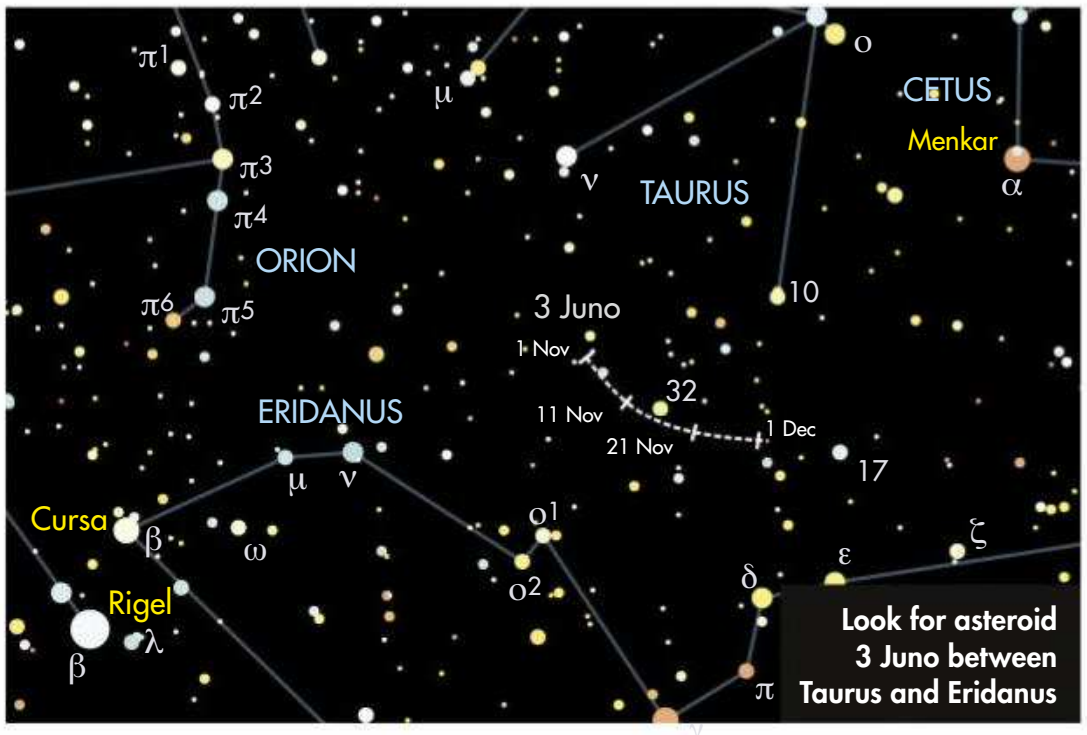
Also in the east of the marsh is the singular but wide crevasse **Rima Hesiodus**. This runs for about 275km from a point just north of the northern edge of Capuanus to a point on the edge of 43km crater **Hesiodus**, on the southern border of Mare Nubium. The 15km **Hesiodus A** abuts the rim of Hesiodus and is remarkable because it's a double-concentric crater: it has both an outer and inner rim. Palus Epidemiarum itself boasts a double-concentric crater in the form of 7km **Marth**, which can be seen between Ramsden and the Campanus-Mercator pair. The inner rims of both these double-concentric craters mentioned are thought to have volcanic origins.

So, despite its decidedly unappealing name, the treasures to be found in and around the Marsh of Epidemics make it worth a closer look.

COMETS AND **ASTEROIDS**

Take advantage of the 11th largest object in the asteroid belt, 3 Juno, at its brightest

Minor planet 3 Juno is one of the 'Big Four' asteroids. This is the name given to the first four objects discovered in the asteroid belt and includes 1 Ceres, 2 Pallas and 4 Vesta. Ceres was reclassified as a dwarf planet back in 2006 but nevertheless the Big Four retain a place in history having been identified in a relatively narrow window between 1 January 1801 and 29 March 1807. It took over 38 years to discover the next one, 5 Astraea.



Juno reaches opposition on 17 November in northern Eridanus. Throughout the month, Juno's brightness hardly varies. It starts at mag. +7.6, increases to +7.5 on 4 November then stays at that value for the rest of the month. This is close to the brightest Juno can achieve, so November offers a great opportunity to observe it. At its dimmest, Juno can dip to mag. +11.6.

Although this month's magnitude means it's a binocular-friendly object, the challenge will be to find it in what is a rather barren area of sky between northern Eridanus and western Taurus. It starts the month in a location slightly west of the mid-point between mag. +3.9 Nu (ν) Tauri and +4.0 Omicron[1] (ο[1]) Eridani, tracking west in an arc that takes it just south of mag. +4.7 32 Eridani

Taking 4.37 years to orbit the Sun, Juno is one of the larger asteroids and is estimated to contain 1% of the mass of the asteroid belt. It's a siliceous or S-type asteroid with an unusually high reflectance of 23.8%. It measures 320x267x200km giving it a mean diameter of 233km. It rotates on its axis once every 7.2 hours.

An asteroid family known as the Juno clump consists of a number of small bodies each less than 6km diameter that orbit within the vicinity of Juno. As they have a similar reflectivity to Juno, it's possible they are debris from impacts on Juno.

STAR OF **THE MONTH**

A dominant multiple star in the Pleiades cluster

At mag. +2.9, Alcyone is the brightest star in the Pleiades open cluster, M45, and the third brightest in Taurus. It's designated as Eta (η) Tauri, a multiple star system that is a genuine member of the Pleiades cluster. The Pleiades is about 100 million years old and is located 444 lightyears from Earth.

Alcyone is a hot, young star of spectral type B5IIIe. 'B5' gives its position within the Morgan-Keenan spectral classification system, which classifies stars by temperature. The 'III' means it's a normal giant-type star; the 'e' indicates that its spectrum has emission lines present.

Alcyone is a little over 2,000 times more luminous than the Sun and 9.3 times as big. Its rotational velocity is high at around 149km/s. For comparison, the Sun rotates at 2km/s. As a consequence, material has spun off Alcyone's equator into a light-emitting disc, the source of the emission lines indicated by 'e' in the star's spectral type.

The main star – Alcyone A – is a triple. A low-mass companion orbits the primary star over a four-day period with a heavier companion, approximately half as massive as the primary, orbiting at a distance similar to that of Jupiter from the Sun.

This system has three orbital companions. Alcyone B and C are 8th magnitude, white A-type stars separated from Alcyone A by 117 and 181 arcseconds respectively. Alcyone C is a Delta Scuti-type variable with a small brightness variation from mag. +8.25 to mag. +8.30 over a period of 73 minutes. Alcyone D is a yellow-white, F-type, mag. +8.7 star located 191 arcseconds from Alcyone A.

Long exposure photographs of the Pleiades reveal blue swirls of nebulous material. This is the result of the cluster stars passing through a cloud of fine dust in space. The light from the brighter stars reflects off this material – typically carbon compounds (eg, diamond dust) with iron and nickel. The particles' size makes them particularly good at scattering blue light.

▲ **The nine brightest stars in the Pleiades, although Alcyone is a multiple star system in itself**

STEPHEN TONKIN'S

BINOCULAR **TOUR**

The keyword this month is 'colour' in a journey around Cetus in search of some unusual stars

☑ Tick the box when you've seen each one

1 THE PISCES PARALLELOGRAM

10x 50 Binoculars are ideal for enhancing the colours of stars as a look at the 3°x1° Pisces parallelogram proves. The northeast corner is 29 Piscium, a brilliant, blue-white star while, diagonally opposite, is the bright orange 30 Piscium. The other two corners – 27 and 33 Piscium – are a muted yellow in comparison. The northern part of the parallelogram appears empty of stars, but very dark skies or larger apertures show this to be an illusion, as a smattering of fainter stars come into visibility. ☐ **SEEN IT**

2 POXON'S TRIANGLE

10x 50 Starting at 33 Piscium, drop down 5° to 3 Ceti, then about the same distance again to 6 Ceti. This is the northern point of a triangle that has 2 and 7 Ceti at its other points. This is a lovely starfield containing stars with a wide range of magnitudes and colours no matter what size binoculars you use. Even when it is quite low, 10x50s should reveal a dozen or more stars, but you may see 30 or more in good conditions. ☐ **SEEN IT**

3 T CETI

10x 50 From 7 Ceti, navigate 2° to the southeast, where by far the reddest star in the region is the unusual, semi-regular variable T Ceti. It is a red giant with technetium in its spectrum. Technetium's most stable isotope, Tc98, has a half-life of 4.2 million years, which – since the star is billions of years old – provides irrefutable evidence for stellar nucleosynthesis. Its semi-regular nature (with a mean period of 159 days) means that it is not entirely predictable but, with a magnitude range of +5.0 to +6.9, it is always accessible to small binoculars. ☐ **SEEN IT**

4 SILVER COIN GALAXY

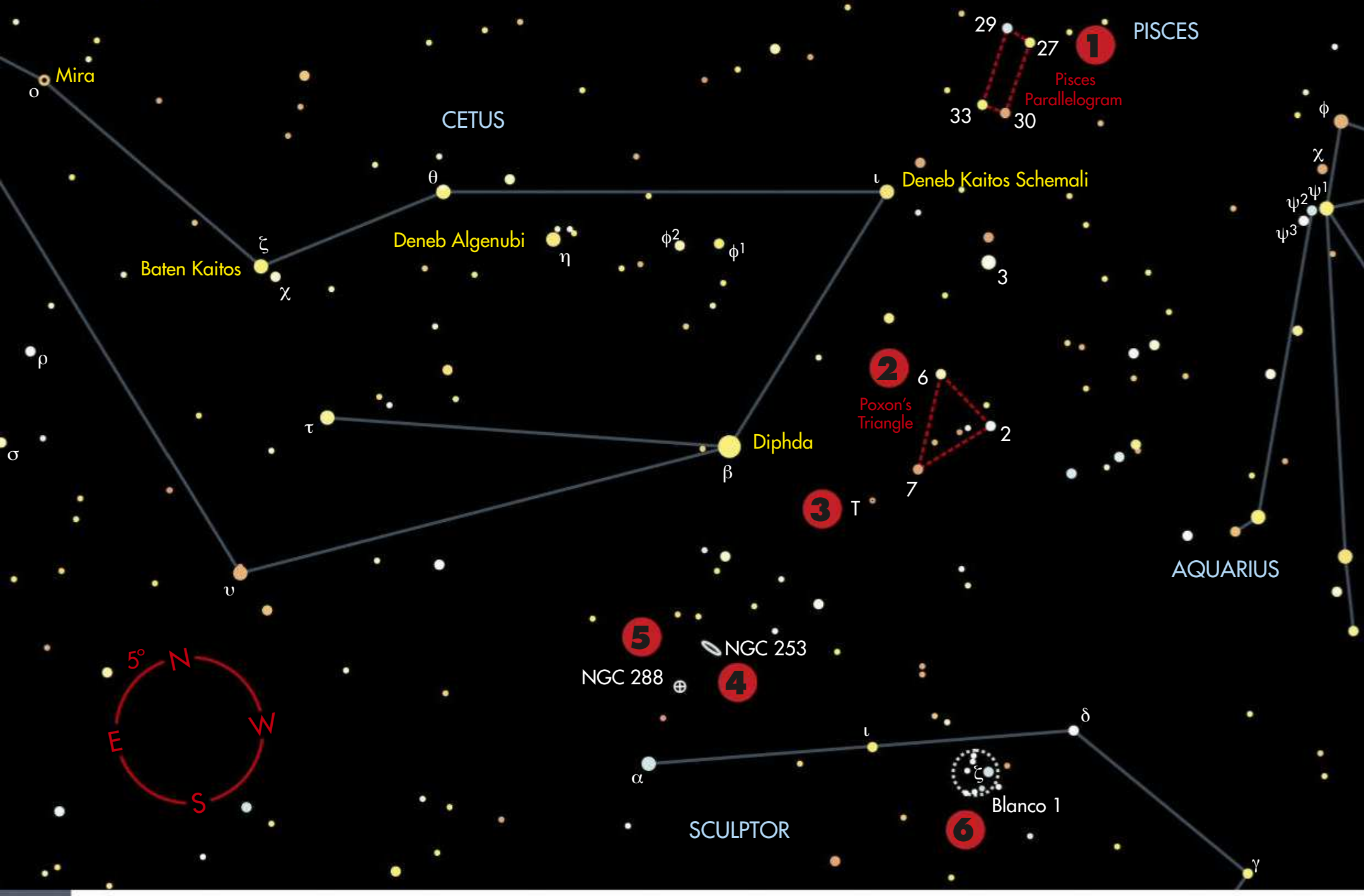
10x 50 Slightly more than 4° to the south of Diphda (Beta (β) Ceti), you will find a right-angled triangle of 5th magnitude stars. NGC 253, the Silver Coin Galaxy, is an elongated glow nearly 3° to the south of this triangle. Its major axis is about half a lunar diameter, and it has a noticeably brighter core. Despite its low altitude viewed from the UK, this galaxy is still a relatively easy object for small binoculars as long as you have a decent southern horizon. This is the best time of year for us to observe it in the evening. ☐ **SEEN IT**

5 NGC 288

15x 70 From the Silver Coin, pan about 2° towards Alpha (α) Sculptoris. Here lies the mag. +8.1 globular cluster, NGC 288, another easy object so long as you have a clear southern horizon. In a pair of 15x70 binoculars it appears as a dim circular glow, which, with averted vision, grows to about half the diameter of NGC 253. NGC 288 is a good marker for the Milky Way's south pole, which lies slightly more than 0.5° away to the south-southwest. ☐ **SEEN IT**

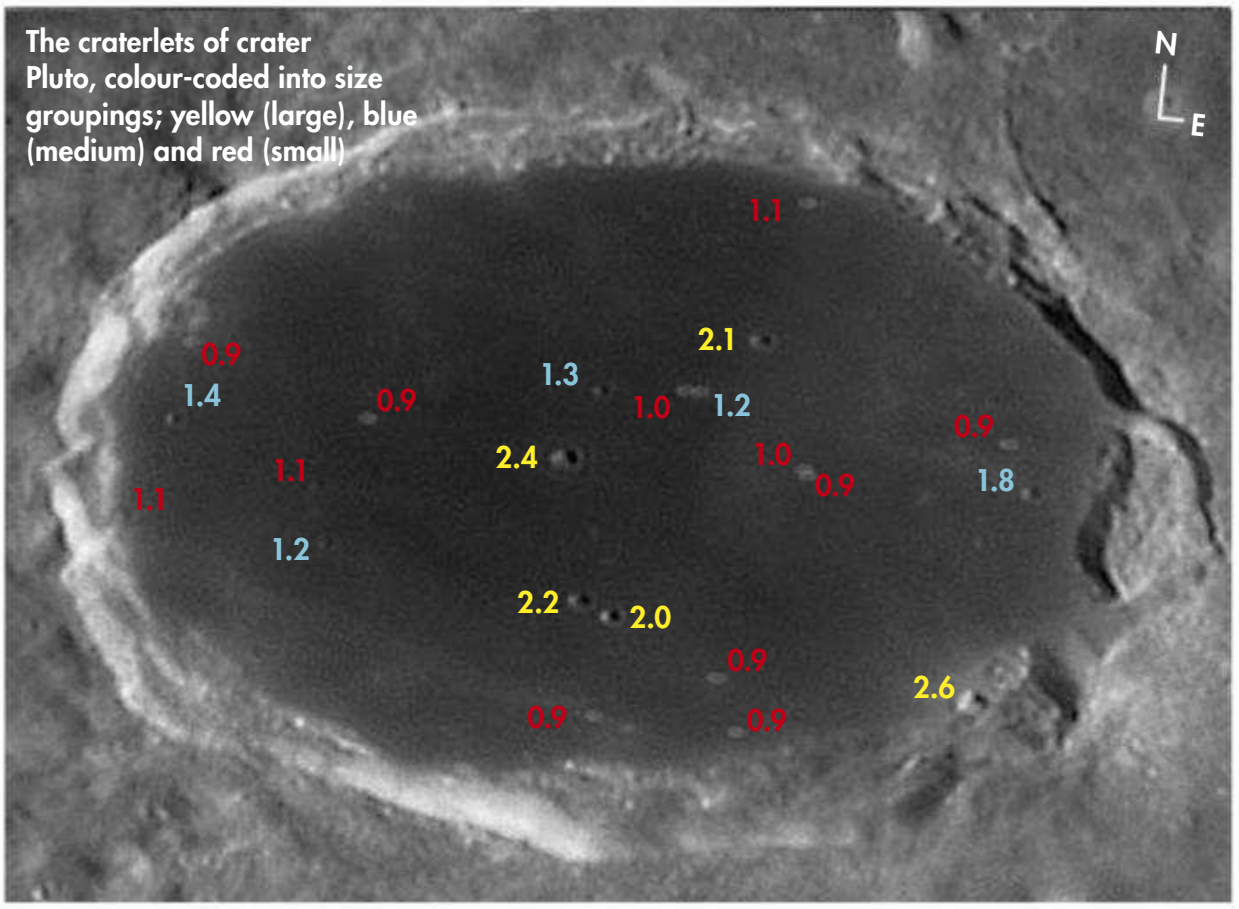
6 BLANCO 1

15x 70 Stick with larger binoculars for the final object to compensate for its low altitude. Identify Zeta (ζ) Sculptoris and get it in your field of view. Notice how it is the brightest of a sparse, indistinct grouping of white stars that span a region about 1.5° wide? Seventy years ago, Puerto Rican astronomer Victor Manuel Blanco did exactly that, and realised that he was looking at a dispersed open cluster. This sole Blanco object is thought to be less than 150 million years old and is 850 light years away. ☐ **SEEN IT**



THE SKY GUIDE **CHALLENGE**

Crater Plato's apparently smooth surface is not quite as featureless as its first appears



The craterlets of crater Pluto, colour-coded into size groupings; yellow (large), blue (medium) and red (small)

The Moon presents some great challenges. One of them can be found within the rim of the dark, flooded crater Plato, a distinctive feature on the Earth-facing side of the Moon, which sits on the northern shore of the large basin known as Mare Imbrium, the Sea of Showers. With a diameter of 100km, Plato stands out because its dark floor contrasts with the surrounding bright highlands.

On first glance Plato's floor looks smooth and rather featureless. This is due to the lava that once flowed within it having levelled out before solidifying. The challenge relates to the tiny craterlets that litter Plato's floor. You can see some with a small aperture starting at, say 3-inches depending on the seeing conditions. To see the majority of them you'll need a larger scope or a high-resolution imaging setup. Your timing needs to be right too, because lighting greatly affects the visibility of these tiny indentations.

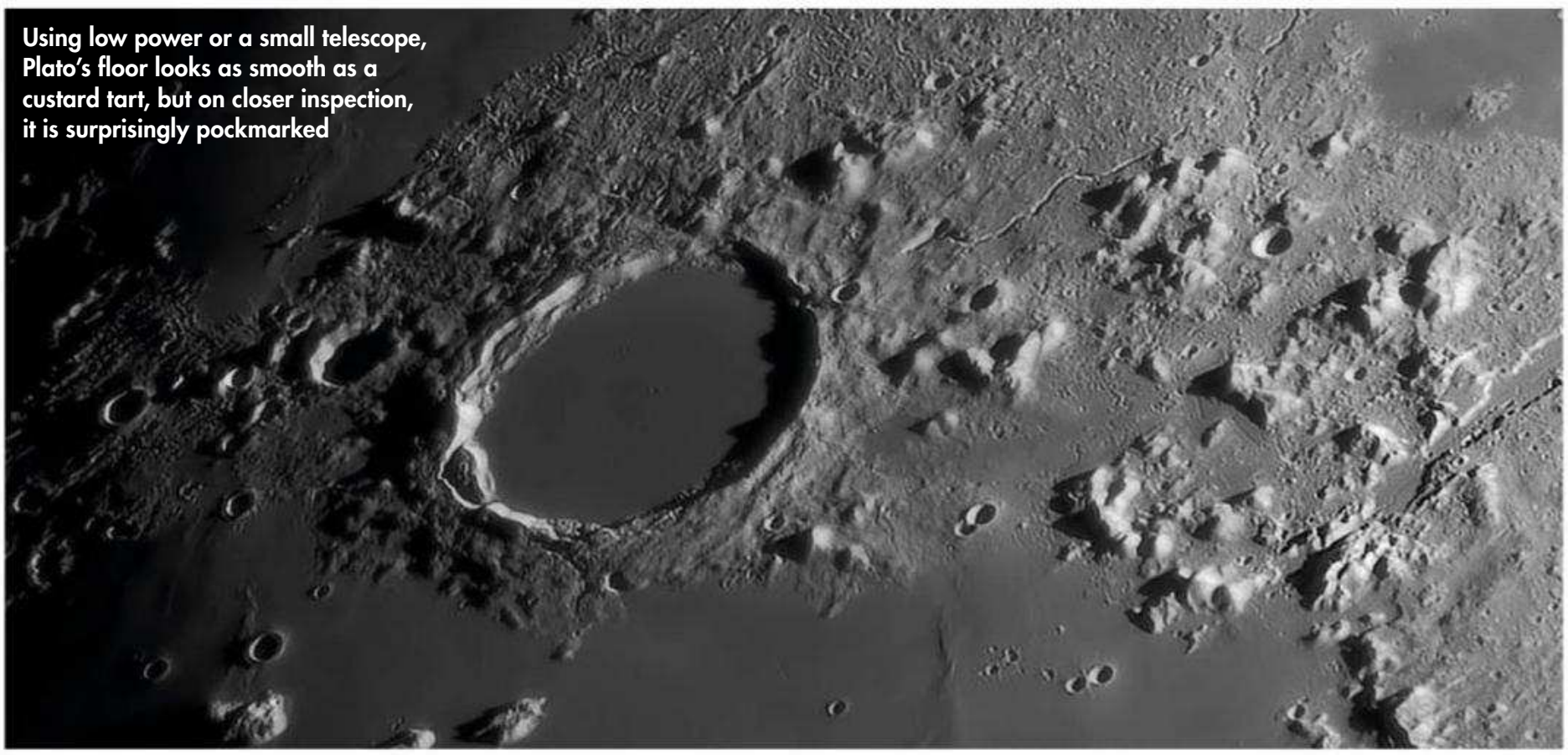
Normally the best time to view lunar relief features is when the terminator is close by. At such times the oblique lighting from the Sun casts shadows that make these features stand out more. Does this apply for craterlets in Plato's floor? Well, yes and no. Yes, because many of them have small, raised rims which do indeed cast shadows when the Sun is low in their sky. No, because the direct illumination that you get closer to a full Moon can make some of the craterlets stand out as tiny bright spots.

Experimentation is the best strategy and it's definitely worth noting how many craterlets you can see at different phases. Seeing has a large part to play, too: if it's poor, your ability to resolve these tiny features is reduced.

For convenience the craterlets can be divided into size-based groups. Group one (yellow on the image) covers the five largest craters which have diameters ranging down in size from 2.6km to 2.0km. Small scopes with apertures from 3 to 5 inches should cope with these, depending on seeing.

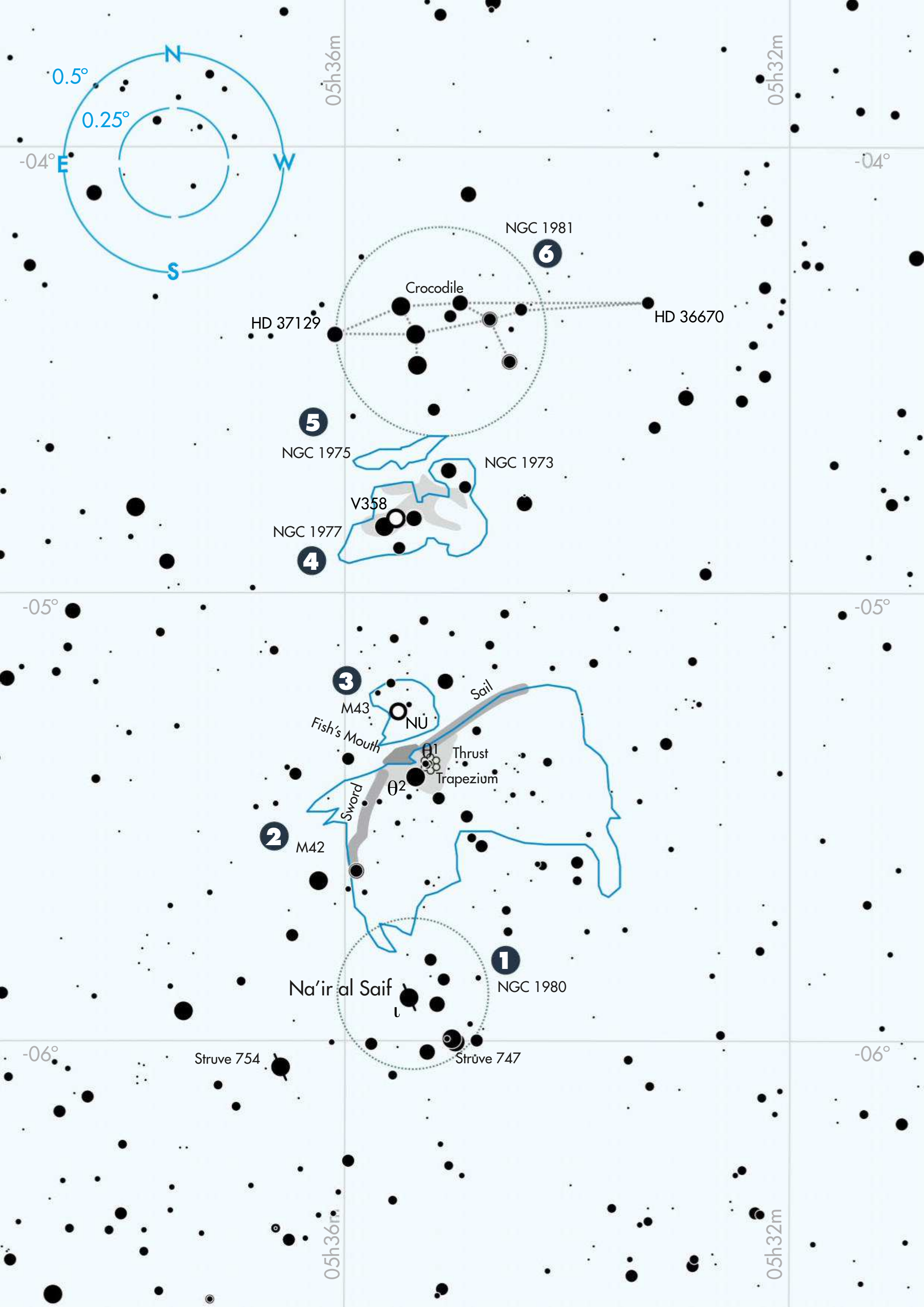
Group two (blue) comprises a further five craters ranging down in size from 1.8km to 1.2km. The largest of these should be visible under good seeing through an 8-inch instrument, but you'll need a larger scope to stand a chance with the rest.

If you've managed to see the craters in Groups one and two purely visually, pat yourself on the back. If you've struggled with some of them then consider using a high frame-rate planetary camera setup. Unless you have access to a very large scope, an imaging route is definitely recommended for Group three (red). This is the toughie, containing 12 craterlets ranging in size downwards from 1.1km to 0.9km. Even with digital imaging on your side, don't expect an easy ride with Group three.



Using low power or a small telescope, Plato's floor looks as smooth as a custard tart, but on closer inspection, it is surprisingly pockmarked

PETE LAWRENCE X 3


N
E
W
S
0.5°
0.25°
05h36m
05h32m
-04°
-05°
-06°
NGC 1981
6
Crocodile
HD 37129
HD 36670
5
NGC 1975
NGC 1973
V358
NGC 1977
4
3
M43
NU
Fish's Mouth
Sail
θ1
Thrust
Trapezium
θ2
Sword
2
M42
1
NGC 1980
Na'ir al Saif
ι
Struve 754
Struve 747

DEEP-SKY TOUR

The Orion Nebula is far from the only object of interest along Orion's sword

☑ Tick the box when you've seen each one

1 NGC 1980

The south of Orion's Sword is marked by open cluster NGC 1980. This appears to include mag. +2.8 Na'ir al Saif (Iota (ι) Orionis) although in reality this is a foreground multiple star system with three components. Iota A is a spectroscopic binary. Two additional doubles help bring interest to this rather sparse open cluster. They are Struve 747 (mag. +4.8/+5.7, separation 36″, PA 223°) and Struve 754 (mag. +5.7/+8.9, separation 5.2″, PA 287°). The cluster appears 0.25° across and is an easy target for a small scope. Interestingly, foreground Iota is possibly a runaway star, the result of a collision between two binary star systems in the Trapezium Cluster (Theta^1 (θ^1) Orionis). Other associated runaways are AE Aurigae and Mu (μ) Columbae. ☐ **SEEN IT**

2 M42

Our next target needs no introduction. M42, the Orion Nebula, dominates the southern half of Orion's Sword. The nebula is an easy small telescope target, characterised by a bright kidney-shaped core called the Thrust, which contains a small open cluster known as the Trapezium. Two distinctive wisps of nebulosity sweep back from the Thrust and are named the Sail and, somewhat confusingly, the Sword. One of the fascinations with M42 is tracing these faint strands. Visually, the nebula is bright enough that you can see its green hue, typically associated with a low-probability electron transition in doubly ionised oxygen. M42 is about a degree across and lies at a distance of 1,344 lightyears, giving a physical dimension of 24 lightyears. ☐ **SEEN IT**

3 M43

A dark triangular inlet into the Thrust on the northern edge known as the Fish's Mouth connects with a dark lane appearing to divide M42 from M43, de Mairan's Nebula. This is a distinctive, comma-shaped patch of nebulosity, dimmer than M42 at mag. +9.0. Like M42, M43 is a glowing HII region – a cloud of predominantly ionised hydrogen gas. If you imagine M43 as a circle, a dark cloud appears to clip out the eastern quadrant giving rise to the nebula's comma shape. M43 has an apparent size of 20x15 arcminutes. An irregular variable, NU Orionis, sits at its centre and exhibits a small variability between mag. +6.8 and mag. +6.9. ☐ **SEEN IT**

4 NGC 1977

Heading north up the sword brings you to a distinctive bent line of three stars. These are relatively bright at mag. +5.2, mag. +7.3 and mag. +4.6 (east to west), although the dimmer, middle star, V358 Orionis, is slightly variable. This region is permeated by a diffuse reflection nebula known as NGC 1977. This has gained notoriety amongst astrophotographers because long exposures reveal a series of darker lanes crossing the nebula. Together these give the appearance of a stick figure in mid stride earning it the name the Running Man Nebula. Visually the nebula is fairly straightforward through larger instruments and it's definitely possible to detect some of the darker lanes. However, the Running Man is a very tough challenge for the eye. ☐ **SEEN IT**

THIS DEEP-SKY TOUR HAS BEEN AUTOMATED

ASCOM-enabled Go-To mounts can now take you to this month's targets at the touch of a button, with our Deep-Sky Tour file for the EQTOUR app. Find it online.

5 NGC 1975

As we've already included NGC 1977, it seems only appropriate to point out that the Running Man Nebula is only one of three nebulae that go under the umbrella name of Sh2-279 (Sharpless 279). Technically this also covers our last target, NGC 1981, as well. NGC 1973 is the brighter patch of nebulosity surrounding the two pairs of stars to the north-northwest of the bent line described above. NGC 1975 is the northern 'cap' on the Running Man nebulosity. These regions are quite indistinct and don't have any absolute divisions from the general NGC 1977 glow. It's an interesting exercise with a low to mid-power eyepiece on a large scope to note just how much detail you can see in this region. ☐ **SEEN IT**

6 NGC 1981

Open cluster NGC 1981 marks the northern end of Orion's sword just as open cluster NGC 1980 (target 1) marks the southern end. Like its southern counterpart, NGC 1981 is quite sparse, but it's larger, occupying an area approximately 0.5° across. Its brighter members shine between mag. +6.5 and mag. +7.5 and form an interesting pattern, which some liken to the shape of a crocodile. If you've never noticed that before, this is one of those moments when your view of NGC 1981 will change forever. The star HD 37129 marks the creature's snout and HD 36670 the end of its tail. The stars in between describe its body with its front and back legs hanging towards the south. ☐ **SEEN IT**

◂ The Orion Nebula with NGC 1977 above it and the bright 'star' Na'ir al Saif (actually a multiple system itself) below

YOUR BONUS CONTENT

Print out this chart and take an automated Go-To tour

CHART: PETE LAWRENCE, PHOTO: CEDIC TEAM/CHRISTOPH KALTSEIS/CCDGUIDE.COM

ASTRO**PHOTOGRAPHY**

▲ When different regions of a DSO require different exposures, you need to combine two shots

High dynamic range Orion Nebula

RECOMMENDED EQUIPMENT

A DSLR and a telescope with a focal length of 1,000mm or shorter

THE BIG PICTURE

COMBINING TWO IMAGES INTO ONE WITH LAYER MASKS

With the return of M42, the Orion Nebula, to UK skies this month, we take a look at how to image this popular target with an extended dynamic range. Unusually for a deep-sky object, the core part of M42 is bright enough for over-exposure as you attempt to record the fainter outer wisps. Using layer masks it's possible to combine images of the core with those showing the outer nebulosity, revealing the whole dynamic range of the object in a natural-looking manner. This technique is a good tool to have in your repertoire as it can also be applied to some other bright deep-sky objects too.

Messier 42, the Orion Nebula, is a very popular target for astrophotography, and for good reason too. It's bright, colourful, easy to find and shows a wealth of detail. If you're not that experienced, the bright core region, known as the Thrust, provides a good practice target. Then, as experience grows, you can concentrate on the glowing outer wisps of nebulosity.

Here you'll run into a problem; how can you retain the beautiful detail and colour in the Thrust region while pulling out the faint outer wisps? Modern cameras can go some way toward doing this when used in conjunction with image processing techniques. These involve stretching the image to accentuate its dimmer parts while not losing the brighter core.

However, a similar, and possibly more visually natural, result can be achieved by sacrificial imaging. Here you concentrate on one area at the expense of the other. For example, longer exposures can be used to pull out the faint wispy stuff allowing the core to over-expose to white. It's sometimes difficult to do this as an imager because it just feels wrong to let it happen. The core is even easier to image because you just need to make sure the inner region exposes correctly and not worry about capturing the outer stuff.

Both bright and dim images should ideally be approached using regular deep-sky imaging techniques. This requires taking multiple images, which are then calibrated using dark frames and flat fields to ensure the best quality. However, if you're new to imaging and don't feel comfortable with calibration, registration and stacking, there's no reason why this can't be done with single images to start with.

If you do decide to go the advanced route, basic calibration involves removing hot-pixels and vignetting from your light frames – that's the term used to describe the images of the actual subject matter. Freeware such as DeepSkyStacker (deepskystacker.free.fr/english/index.html) can do this for you but you still need to create the calibration data. Hot pixels – unnaturally light pixels caused by tiny sensor imperfections – can be corrected by covering the telescope aperture after you've taken a set of light frames. By taking another set of shots at exactly the same exposure, the resulting dark frames will isolate the hot pixels present in the light frames (they're always in the same place); they can now be easily subtracted from the light frames.

Flats are a little more complex. You need to point the imaging telescope at an evenly illuminated light source and take images that saturate the camera sensor to about 50-70%. The saturation can be determined by the position of the peak spike in the histogram display for the image.

Random thermal noise in each image requires a number of darks and flats to be taken and averaged together. This reduces the background noise according to the square root of the number of images involved. For example, if four images are used, the noise is reduced to a half its original value. If nine images are used, the noise is reduced to one third.

Although this may sound complicated if you're just starting out, programs such as DeepSkyStacker do much of the donkey work. Your job is to make sure the images you supply it are focused and tracked as accurately as your equipment will allow.

✉ Send your images to: hotshots@skyatnightmagazine.com

ALL PICTURES: PETE LAWRENCE

STEP BY STEP

STEP 1

For this process we'll assume we're using a DSLR attached to a telescope, shooting single (non-stacked) images. For best framing, a telescope focal length of 1,000mm or shorter is recommended. Placing M43 close to the middle of the long frame edge works well but make sure it's got enough 'space-border' so the final image doesn't look cramped.

STEP 2

Now focus as accurately as possible. The Trapezium cluster in the centre of M42 is ideal for this. Using Live View, the four brightest cluster stars should appear sharp and separated. Once done, set the camera ISO to a low or middle value. Low gives better tone and image quality, but if your tracking isn't perfect, a middle value allows shorter exposures.

STEP 3

Concentrate on the outer regions. Take test exposures to ensure you're capturing the faint detail. Don't worry if the overall image looks bright. If the core is looking white because of overexposure you're probably on the right track! A simple way to correct such an image is to dim it using the levels mid-point slider, then tweak the brightness and contrast.

STEP 4

Capturing the inner Thrust region is more straightforward because it doesn't require such a long exposure. A good technique is to bracket your exposures. Identify what you think is the optimal exposure then use incrementally shorter exposures, followed by incrementally longer ones. Now you're covered if your original assessment was a bit off.

STEP 5

You should end up with one deep image with lots of faint stuff visible and another which only includes the core region. Open both images in a layer-based editor, the deeper result on top. Align them so the stars match. Draw a selection region, roughly tracing the border of the over-exposed core. Copy the selection to the clipboard.

STEP 6

Paste the selection as a layer mask for the upper layer. In Photoshop, this means holding down the alt key while clicking the new layer mask button. Click the layer mask in the layers display and apply a fairly large Gaussian blur so the sharp edges disappear. Tweak each layer using Curves until the combined result looks natural to the eye.

NASA's Curiosity rover takes a dusty selfie on 15 June as a global dust storm rages across Mars and dramatically reduces visibility

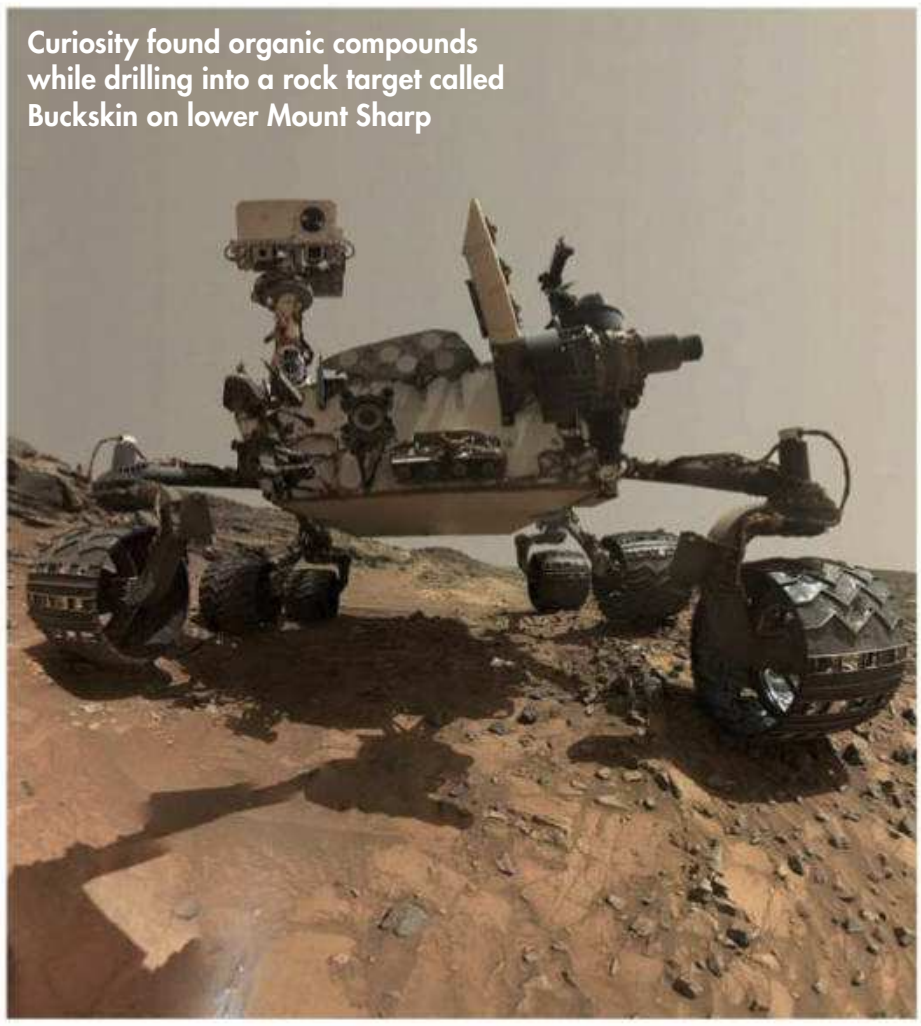
NASA/JPL-CALTECH/MSSS

6 months on MARS

A giant dust storm, an underground lake and new possible hints of life... it's all been happening on the Red Planet, as **Elizabeth Pearson** explains

On 26 November, after six months of interplanetary travel, the InSight lander will set down on the surface of Mars and start probing deep beneath the planet's surface. But we've learned a lot about the Red Planet in the six months since InSight left Earth. Mars has made its closest approach to Earth since 2003; we've discovered the ingredients for possible life on the surface; and the planet's atmosphere has been ravaged by extreme weather conditions. As the latest Martian spacecraft prepares to move into its new home, we take a look back at the biggest headlines that have come from the Red Planet since it started its journey.

ABOUT THE WRITER
Dr Elizabeth Pearson is *BBC Sky at Night Magazine*'s news editor. She gained her PhD in galactic astronomy at Cardiff University



Curiosity found organic compounds while drilling into a rock target called Buckskin on lower Mount Sharp

ORGANICS found on Mars

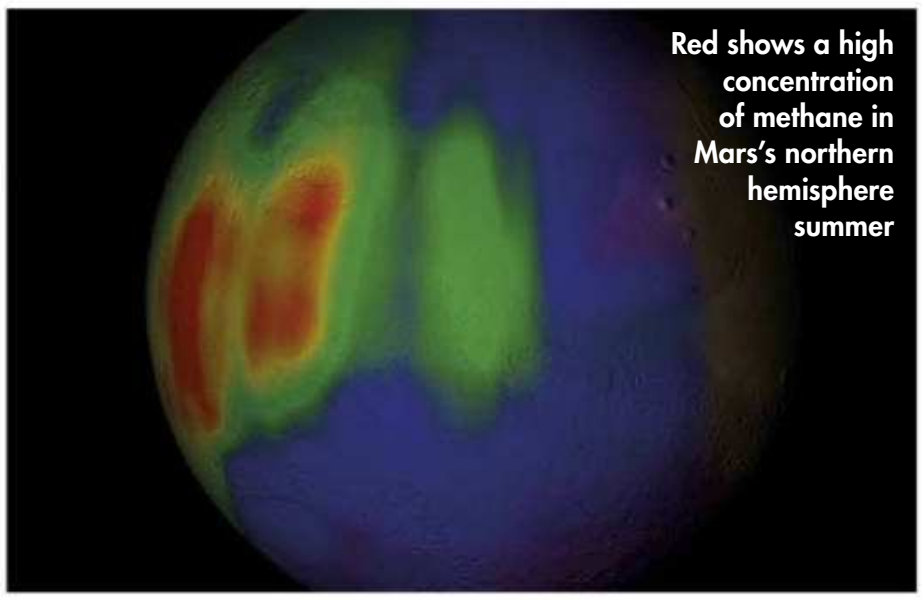
Chemicals have been found that could have led to life in Mars's past, but the discovery's still not a clincher

JUNE

For decades, missions to the Red Planet have been driven by one question: is there life on Mars? NASA appeared to be one step closer to finding an answer when, in June, the agency announced that Curiosity had discovered complex organic molecules – carbon-based compounds from which all life is built – in Martian rocks. However, just because they are organic doesn't mean they are biological.

"In some cases, they can be geochemical or come from meteorites," says Richard Zurek, chief scientist of NASA's Mars Program Office. However, the fact that Curiosity had to heat them to high temperatures could provide a clue to their origin. "That means you're breaking down longer carbon chains, which is more of an indicator of biogenic processes." But it is still just an indicator.

"This rock is over a billion years old. That means if life ever developed on the planet then the organic material that has been left behind has been preserved and we can find it," Zurek concludes.



Red shows a high concentration of methane in Mars's northern hemisphere summer

Martian METHANE

More gas appears in the atmosphere over the summer

JUNE

While the planet's rocks might reveal secrets from Mars's past, hints of methane in the atmosphere could hint at life on the planet right now. The gaseous discovery was confirmed in research published in June, based on five years of data collected by NASA's Curiosity rover.

"There shouldn't be any methane on Mars as it only takes about 300 years for it to break down in the atmosphere. That means either something is resupplying it, or our ideas about how methane is destroyed are wrong," says Zurek.

One clue to its origin may be that levels fluctuated with the seasons, with higher levels during the northern hemisphere's summer and autumn. "Methane can be produced by other chemicals reacting with the rock," says Zurek. "But on Earth most methane is generated organically. So maybe it's a trace gas that says there's current life on Mars."

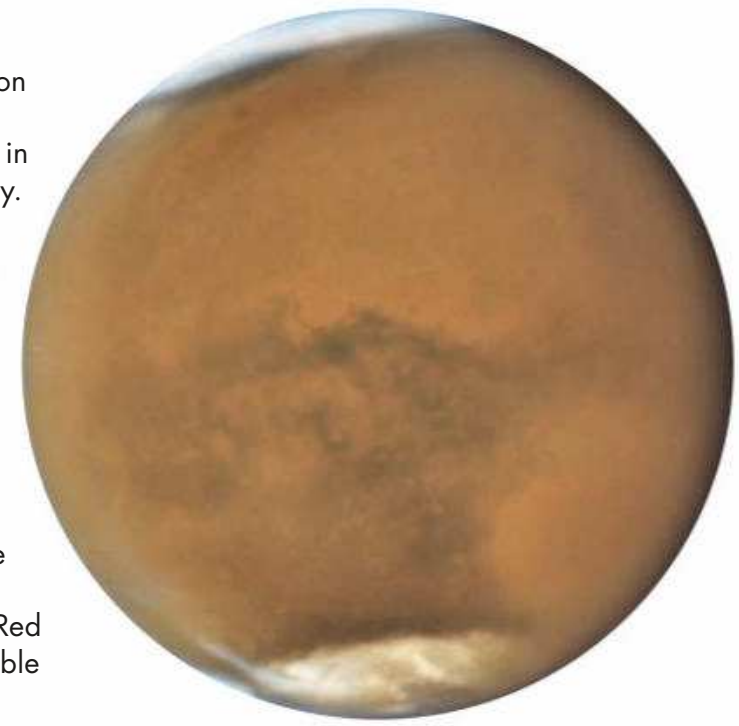
NASA/JPL-CALTECH/MSSS X 2, NASA/ESA AND STSCI, NASA, ISTOCK, NASA/JPL-CALTECH, ESA/ATG MEDIALAB

Close ENCOUNTER

Mars came to within just 57.6 million km of Earth, which is the nearest the pair has been for 15 years

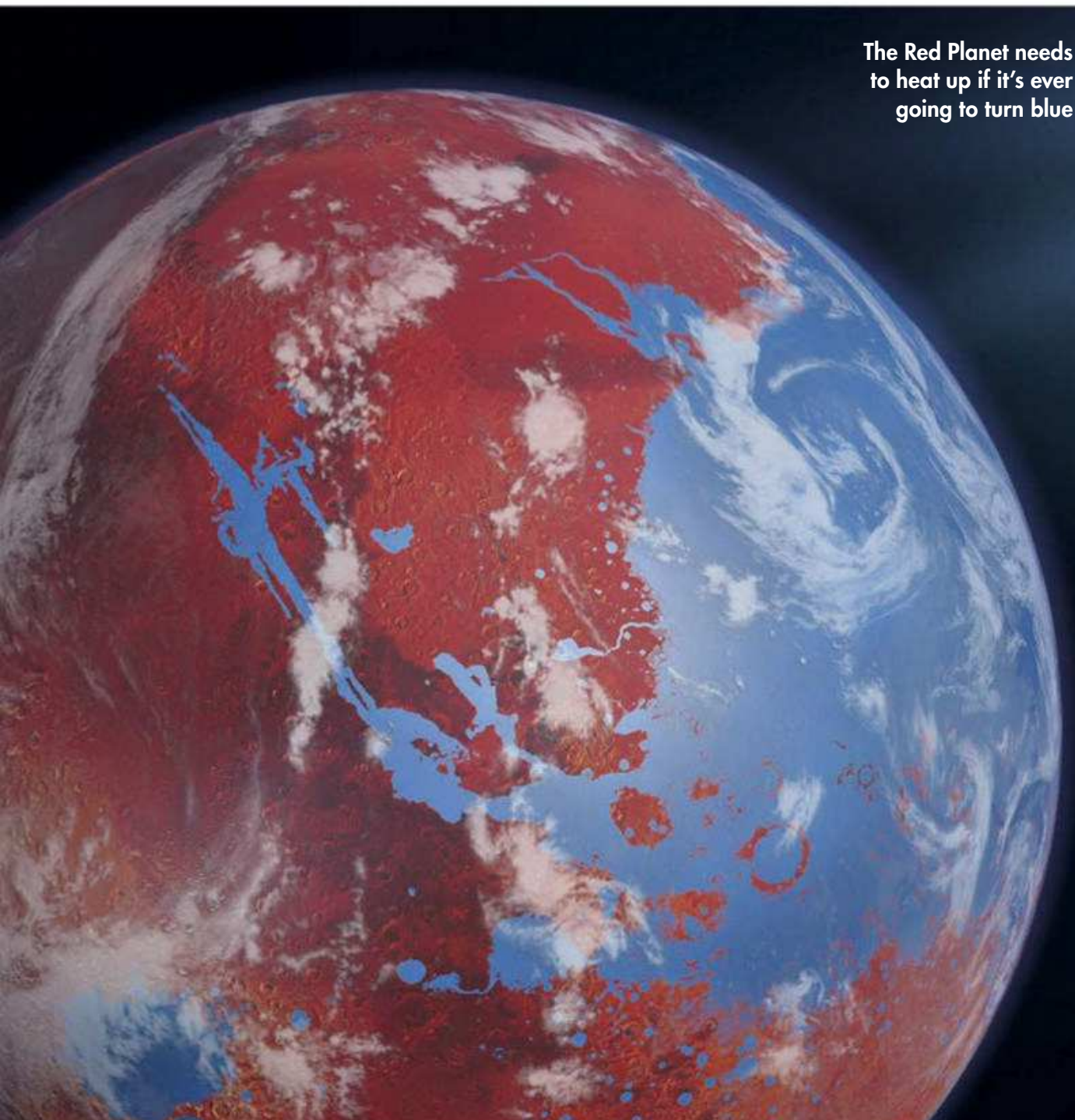
JULY

Mars was at opposition – when the Sun, Earth and Mars align in that order – on 27 July. The planet was a mere 57.6 million km from Earth, the nearest it has come since 2003. During opposition, Mars appears bigger and brighter in the night sky. UK sky watchers were treated to a rare sight on the day of opposition when the Red Planet was briefly visible alongside the red Moon of a lunar eclipse – in the few places that weren't completely clouded out, that is.



▲ Mars on the day of opposition, shrouded in a massive dust storm, captured by Hubble

One telescope that doesn't have to worry about bad weather is the Hubble Space Telescope. It took advantage of the close pass to snap a new pair of 'family photos' of both the Red Planet and Saturn, which was also going through opposition. The planet's features are slightly blurred in the photo, but not by the seeing that often affects images of Mars taken from inside Earth's atmosphere. Instead, the haze of a giant dust storm on Mars was to blame.



The Red Planet needs to heat up if it's ever going to turn blue

Turning the Red Planet BLUE

Terraformers with plans for Mars might have had their hopes dashed

JULY

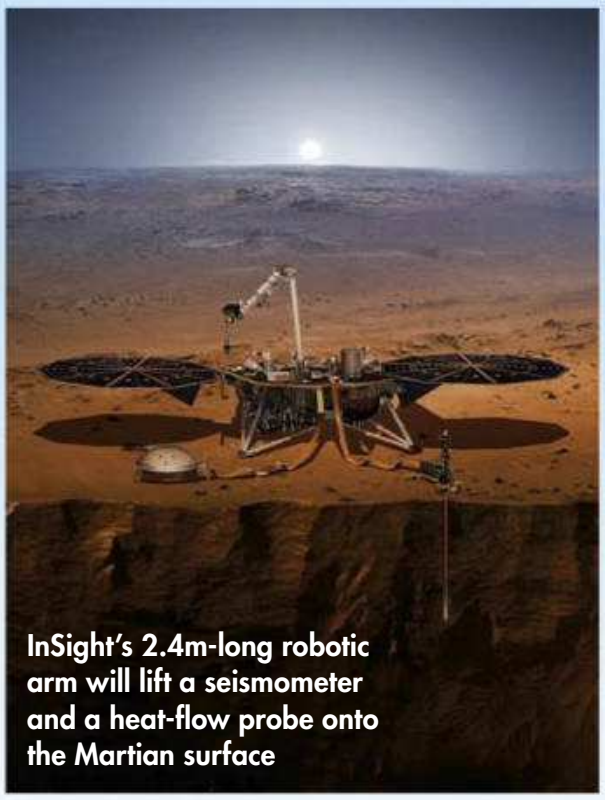
A century ago, many scientists believed that the surface of Mars was crossed by canals and teeming with life. Today, we know it is a dry and seemingly dead world, but there are still those who dream of bringing liquid water and life to the surface of Mars via terraforming – manipulating another planet to make it more Earth-like.

One of the key steps in terraforming Mars is increasing its temperature. It's been suggested by the likes of SpaceX CEO Elon Musk that releasing carbon dioxide locked up in the planet's rocks could create a layer of greenhouse gases, which would increase the temperature.

There's one problem, however: it turns out there's not enough carbon dioxide on Mars. A recent study found that even if all the carbon dioxide on the planet was released the pressure would only rise to seven per cent that of Earth's – nowhere near the levels needed to make a Red Planet blue. ▸

FUTURE MISSIONS TO MARS

We can expect to hear a lot more from the Red Planet as three new missions will soon arrive on the surface



InSight's 2.4m-long robotic arm will lift a seismometer and a heat-flow probe onto the Martian surface

The InSight lander is due to arrive on the Red Planet in November, where it will attempt to peer right into the heart of Mars. It will feel for seismic vibrations, measure the heat flowing through the crust and gauge the planet's wobble. Combining these readings will allow planetary scientists to work out what's happening in the planet's core.

Then in 2020, not one, but two new rovers will be arriving on the Red Planet in the hope of exposing yet more secrets. NASA's fifth rover, Mars 2020, will hunt for interesting rocks to collect. Rather than analyse them in-situ, as Curiosity does, the rover will create sample caches that future Mars missions will collect and return to Earth.

Meanwhile, ESA is aiming to send its first ever rover to the Martian surface as part of the ExoMars mission. The rover's biggest asset is its 2m long drill, which will be able to take pristine samples of rock that have been hidden from Martian weather and solar radiation.

ESA's ExoMars rover will search for subsurface life in two ways: by structure and by chemistry

MARTIAN NEWSFLASH

More headlines heralding from the Red Planet

▸ We could soon be exploring the Martian skies as NASA's Mars 2020 rover will also have a remote helicopter to test the potential for future drone explorers.

▸ The indents left behind by billion-year-old Martian dunes reveal that the prevailing winds on Mars used to blow in a different direction.

▸ A decade of data from Mars Express has shown that the Martian atmosphere acts as one system, with all layers interacting with each other.

▸ Bacteria from an acidic stream in Dorset could help astrobiologists understand if life was possible under similar conditions on Mars.

▸ Martian spacecraft MAVEN discovered the magnetic 'tail' trailing behind Mars is being twisted by the solar wind, which could allow the atmosphere to escape.

▸ Simulations of the early Martian terrain suggest that Mars's oceans could have appeared several hundred million years earlier than first thought.

▸ ESA ran a competition to name their rover that will head to Mars in 2020. The entries are now being judged.

An image of Mars taken on 28 June by the 1m Chilescope shows its prominent features obscured by the dust storm

DUST STORM on Mars

It's been a dark time for Mars this summer

MAY TO AUGUST

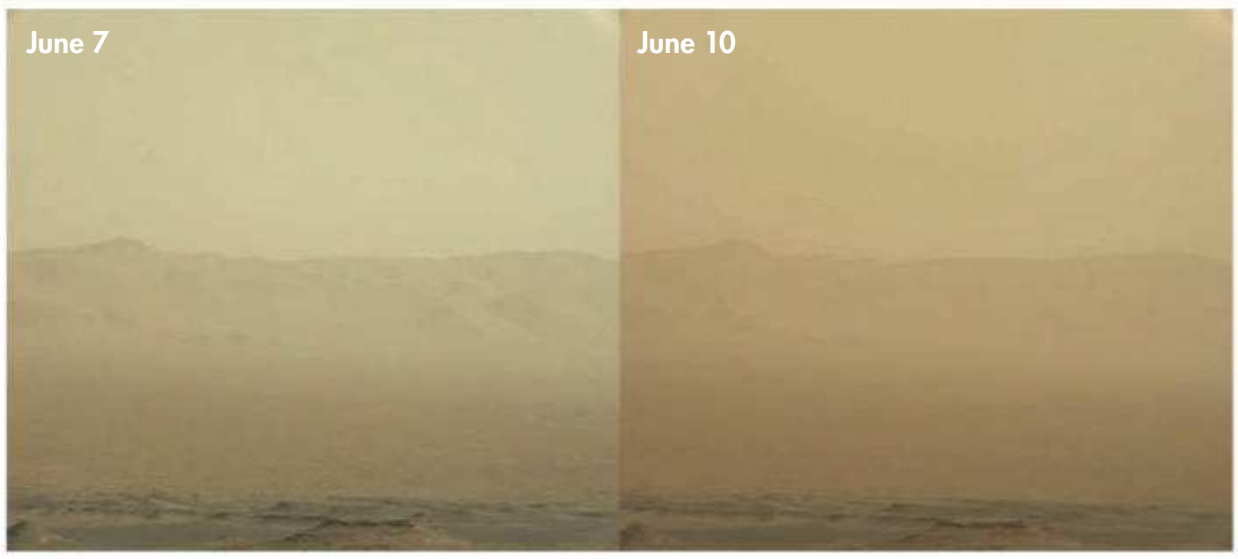
It might have been a sunny summer for the UK, but the same has not been true on Mars. The Sun disappeared from Martian skies as the Red Planet was ravaged by a global dust storm, which went on and on and on…

Mars is engulfed by large, dust-bearing clouds every few Martian years, but previously we've only ever watched them from afar. This year, however, there were four spacecraft in orbit around Mars and two rovers on the ground, giving us a front row seat. In fact, it was the Opportunity rover that gave the first sign a big storm was on its way.

"We measured the dust opacity, that's a measure of the extinction of sunlight as it goes through the atmosphere," says Zurek. "In the last attempted measurement, Opportunity couldn't even find the disc of the Sun."

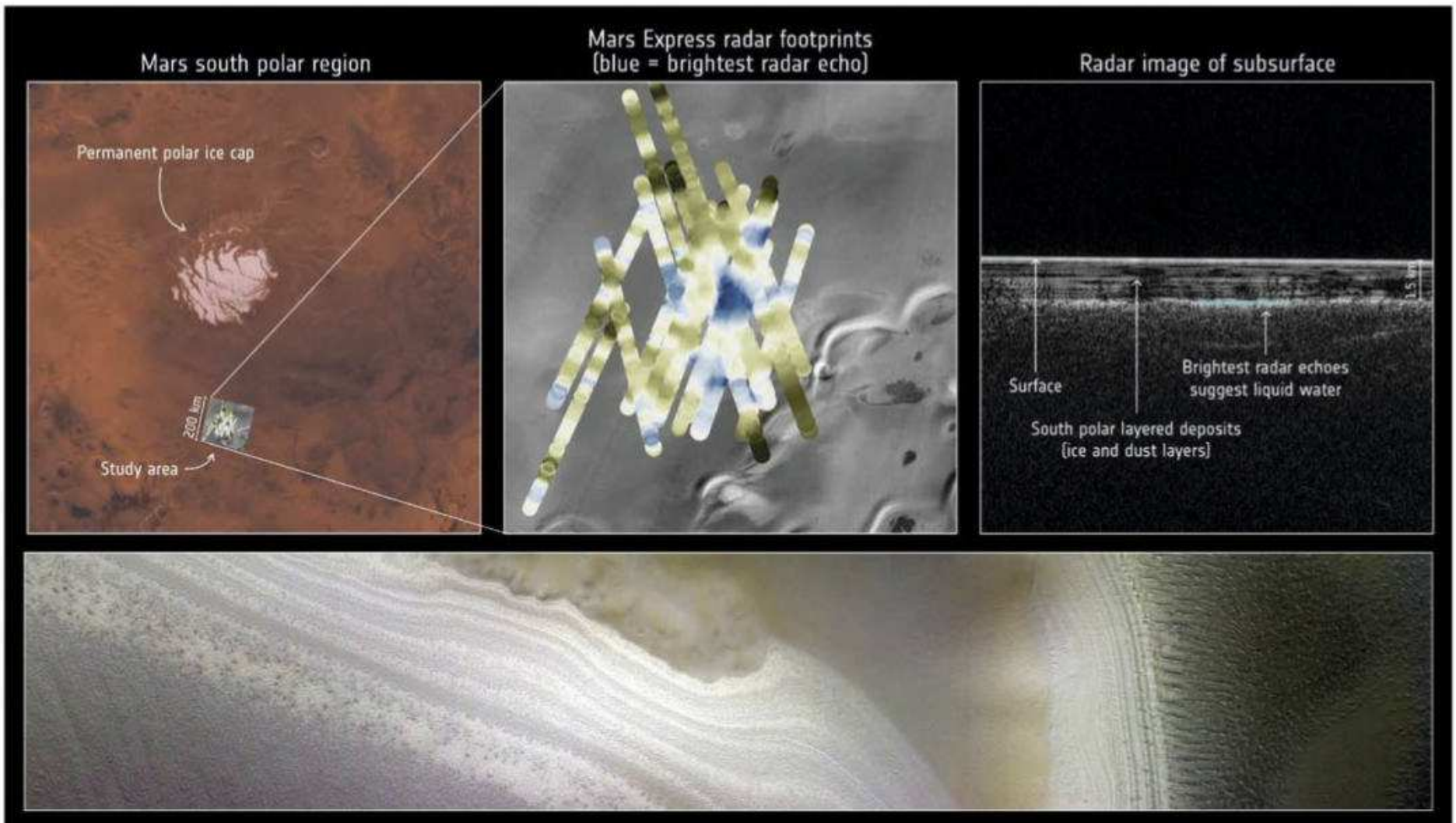
The lack of light quickly proved problematic for the rover as it is solar powered – no sunlight means no power. Opportunity went into hibernation on 10 June and, at the time of writing, had yet to reawaken. However, the other Martian explorers continued to keep an eye on the storm as it grew, blew and then eventually waned at the end of August.

"We're trying to understand the climate of Mars today," says Zurek. "Why in some years are there global storms, but not other years? Eventually we'd like to have better predictions of these events; at least a climate forecast for dust storms on Mars."



▲ Two views inside Gale Crater taken three days apart by Curiosity show Mars darkening

CONTEXT MAP: NASA/VIKING/THEMIS BACKGROUND: NASA/JPL-CALTECH/ARIZONA STATE UNIVERSITY/MARSIS DATA: ESA/NASA/JPL/ASI/UNIV. ROME/R. OROSEI ET AL 2018, D. PEACH/CHILESCOPE, NASA/JPL-CALTECH/MSSS X 2, ISTOCK, NASA/JPL-CALTECH, NASA'S GODDARD SPACE FLIGHT CENTER



▲ Radar data from Mars Express's MARSIS equipment may have found a subsurface lake on Mars under its south pole. Corroborating evidence came in the form of an ExoMars image from May 2018 (bottom) that also revealed layered deposits at the south pole of Mars

THE WATERS OF MARS

A lake could be a likely location for life on Mars, but anything there needs to have a taste for salt and dark places

JULY

Has water finally been found on Mars? In July, ESA announced that radar data taken by Mars Express showed evidence of a lake deep beneath the surface.

"We detected very strong echoes coming from 1.5km below the surface of the south polar cap," says Roberto Orosei, principal investigator of Mars Express's radar instrument, MARSIS (Mars Advanced Radar for Subsurface and Ionosphere Sounding). "They point to the presence of liquid water, the natural material that best reflects radar waves."

As past 'discoveries' of Martian water have turned out to be unfounded, the team checked for other possibilities. After several months, they are convinced their theory remains the best explanation. "It's a body of water 20km across," says Orosei. "We know that the liquid water must be about 1m thick, or else the radar would not be able to see it."

Some have wondered whether the lake could harbour Martian life, but any microbes calling the pond home would need to be extremely hardy. To avoid freezing, the water must be so salty no life as we know it could survive there. But as we would currently struggle to drill through 1.5km of ice on Earth, let alone on another planet, it will probably be some time until we can check what the water's like on Mars.

Curiosity stops transmitting science

The fault seems to lie in the rover's primary computer

SEPTEMBER

On 15 September, Curiosity was drilling in the Vera Rubin ridge when mission controllers realised something was amiss: the science and engineering data they had been expecting wasn't coming in.

The rover was still transmitting 'real-time' data, but this could only be picked up when a relay orbiter or the Deep Space Network was in the correct position. This information revealed that, mechanically speaking, Curiosity was operating normally; the fault was in its rover's computer.

Though at time of writing the exact cause of the problem is unknown, engineers are endeavouring to get the rover back to full working order. If they are unable to fix the primary computer there is a backup they can switch to, though this secondary computer has suffered from hardware and software issues in the past. In the meantime, NASA ordered Curiosity to turn off its science instruments while engineers do their work. As we went to press the official line was, "Mission team members are optimistic they can get the six-wheeled robot up and running again."

With the Opportunity rover also out of action, the Red Planet could be quieter than expected when InSight arrives in November.

▲ Sadly, results from Curiosity's drilling may be a thing of the past unless it can be revived

BBC Sky at Night Magazine Reader Survey

Let us know what you think **for a chance to win a £250 Amazon voucher!**

Would you like to have your say in the development of *BBC Sky at Night Magazine*?

Every year, we carry out research on behalf of BBC Studios that invites readers to share their views about this magazine and other BBC Studios titles.

This essential research is used by BBC Studios and the editors to shape future content and strategy for the magazines. We would really appreciate your time to help us with this research.

To take part in the research and be entered into a prize draw to win a £250 Amazon voucher, please visit: **bbcstudios.com/survey**

The survey will take less than 10 minutes and is being conducted according to Market Research Society guidelines. All of your responses are completely confidential.

BBC Sky at Night MAGAZINE

Terms and conditions: The prize is one £250 Amazon voucher. One winner will be drawn at random after the closing date at 23.59 on 31 December 2018. Open to all residents of the UK and the Channel Islands aged 18 years or over except employees of BBC Studios or the BBC, their contractors, members of their families and anyone connected with this prize draw. Only one entry permitted per person. There is no cash alternative and the prize is not transferable. No purchase necessary. The prize draw is subject to the laws of England and Wales. Promoter: BBC Studios Limited, Television Centre, 101 Wood Lane, London W12 7FA. Your data will be used for the purposes of administration of this prize draw and in accordance with BBC Studios's Privacy Policy (www.bbcworldwide.com/home/privacy/). Where consent has been provided, BBC Studios may send email marketing messages from which you may unsubscribe at any time.

IMAGING FOR SCIENCE

Jupiter is possibly the most photogenic planet in the Solar System, but your images of it could be more than just pretty pictures

Part 7: Jupiter

The latest instalment in our continuing guide to building scientific value into your astrophotos spotlights Jupiter. Learn how you can help map the gas giant and keep track of its atmospheric features

PETE LAWRENCE

As well as its many moons, fast-spinning Jupiter has three different rotational systems

Jupiter is an impressive and substantial disc through the eyepiece, making it an attractive imaging target for scientific analysis. The planet's rapid rotation means all image captures need to be performed quickly, and date- and time-stamped accurately. UT (Universal Time) should be used on all your notes, which should also indicate the image orientation and the longitude at the central meridian. Jupiter exhibits differential rotation: its equatorial zone rotates faster than the rest of the planet. In fact, three longitude systems exist: System I for the equatorial region, System II for the rest of the planet, and System III for Jupiter's radio rotation period (used in professional analysis, such as space-missions like Juno). You can get all three values using software like WinJUPOS. Today, images of this gas giant tend to be presented north-up with F and P markings indicating the [F]ollowing and [P]receeding limbs (a reference to the planet's rotation and how features appear to move on and off its disc). In the case of Jupiter, F is equivalent to east and P west.

Jupiter's longitude rotation systems

System	Rotation
System I (applies to latitudes between +10° and –10°)	9h 50m 30s
System II (latitudes between +10° to +90° and –10° to –90°)	9h 55m 41s
System III (inner magnetosphere period and also the 'official' rotation period)	9h 55m 29.71s

ABOUT THE WRITER
Sky at Night **presenter Pete Lawrence is an astrophotographer with a particular interest in digital imaging**

Hardware & software

HARDWARE

- **High-frame-rate camera**
- **RGB imaging filters for use with mono camera**
- **Speciality filters, eg, IR-pass and methane**
- **Filter wheel**
- **Atmospheric dispersion corrector**
- **Large aperture, long-focal-length telescope on a driven mount**
- **Laptop**

SOFTWARE

- **WinJUPOS (freeware, jupos.privat.t-online.de/index.htm)**
- **Capture software, eg, FireCapture (freeware, www.firecapture.de) or SharpCap (freeware and commercial, www.sharpcap.co.uk)**
- **RegiStax (freeware, www.astronomie.be/registax)**
- **AutoStakkert! (freeware, www.autostakkert.com)**
- **DeTeCt (freeware, www.astrosurf.com/planetessaf/doc/project_detect.php)**
- **Image editor, eg, GIMP (freeware, www.gimp.org) or Photoshop (commercial, www.adobe.com/uk/products/catalog.html)**

STEVE MARSH, PETE LAWRENCE X 3

Submit your pictures for science

"The biggest thing amateurs can offer professional planetary scientists is time," says Alan Clitherow (pictured), director of the Society for Popular Astronomy's Planetary Section.

"Amateurs observing and imaging the planets provide a level of detailed coverage that professionals simply cannot match using their limited number of exotic telescopes, which are constantly in demand for many different observing projects. When the Mars Pathfinder landing was threatened by dust storms it was an analysis of thousands of amateur images that allowed an understanding of the progression of such events and a decision that the landing could continue safely. The current NASA Juno mission relies on amateurs contributing images of Jupiter so that Juno's highly detailed pictures of a small strip of Jovian cloud can be put in a wider context of weather patterns determined from those amateur images.

"Amateur telescopes and cameras can now produce outstanding results. The images are often produced and processed by software written by amateurs, and an amateur team currently coordinates the search for 'impact flashes' – the evidence of asteroid strikes on the face of Jupiter – in videos of the planet taken from any number of backyards worldwide.

"The Society of Popular Astronomy exists to help amateurs of all levels as they progress their interest in the night sky; it allows them to make a real contribution to human understanding of the Universe."

For more information visit: www.popastro.com/main_spa1/planetary

PROJECT 1

Imaging BASICS

Essentials for imaging a fast-rotating, low-altitude planet

► A typical atmospheric dispersion corrector (ADC) contains two counter rotating prisms

▲ A high-frame-rate camera is essential for modern high-resolution planetary imaging

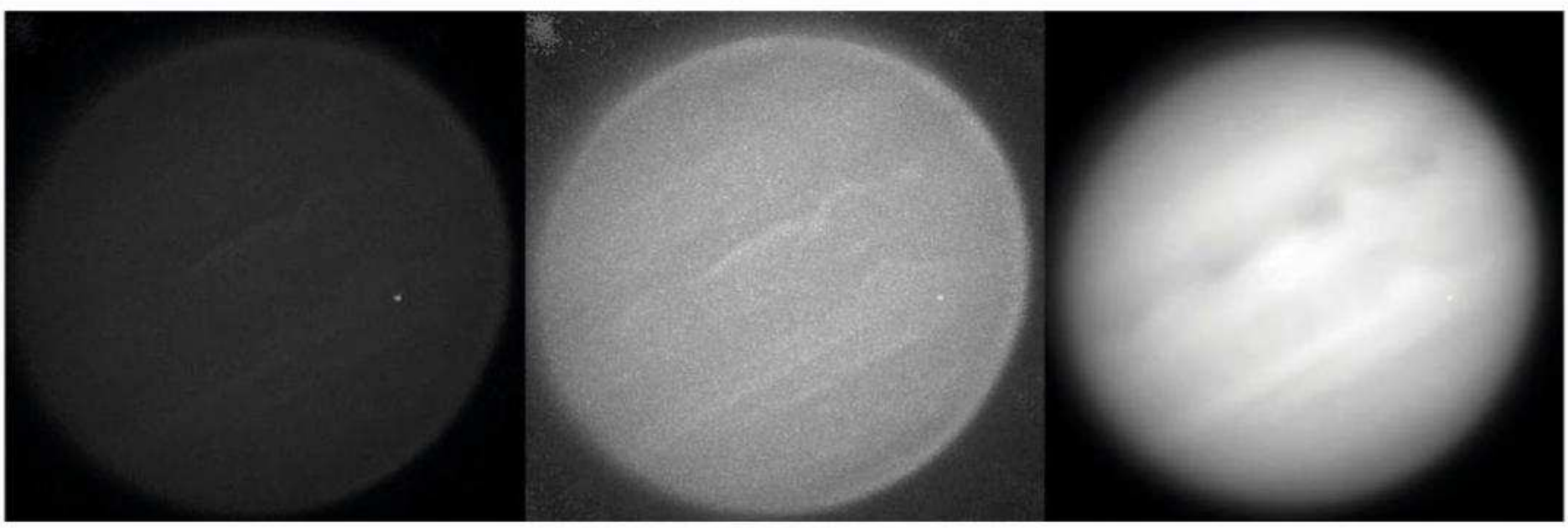
Successful planetary imaging requires unique astrophotographic skills and fast-rotating planets such as Jupiter, Mars and Saturn add extra pressure because motion blur can take place if the capture time is too long.

On top of this, the effect of high speed local atmospheric wobbles (seeing) deteriorates results. High-frame-rate cameras lessen the impact to a degree by taking many still images in rapid succession, which are then processed by registration-stacking software like RegiStax or AutoStakkert. The automatic process involves sorting by frame quality, registering the best frames to one another and averaging these into a single image. Sensitive and fast cameras are essential because what you're attempting to do is sample across the fleeting periods of good seeing which should occur during the capture session. Maximum recording times shorter than 60s or even 30s are recommended so high capture frame rates are very desirable. Software such as WinJUPOS offers the facility to undo many minutes of rotation via a de-rotation function.

Jupiter's visibility from 2018-2023 is further complicated by its low altitude as viewed from the UK. The planet's decreasing height above the horizon makes it more likely that images will exhibit colour fringing from atmospheric dispersion. This can be countered reasonably effectively by using an optical device known as an atmospheric dispersion corrector (ADC) fitted between the camera and the telescope.

An ADC will allow a colour camera to be used on Jupiter at low altitude. Mono cameras will need an RGB filter set to produce colour images. Using an infrared pass filter as well often helps obtain higher contrast results, while taking advantage of the fact that longer wavelengths are less affected by poor seeing. A methane (CH4, 890nm) filter can also be used to good effect on methane-rich Jupiter. This requires a camera with a good response in the near infrared part of the spectrum.

The movie sequences recorded by high frame rate cameras are good candidates on which to carry out impact flash searches. Software such as DeTeCt (www.astrosurf.com//planetessaf/doc/dtc/doc/dtc_tuto_en.htm) looks for the bright transient flashes that may appear on Jupiter's disc as signs of meteors vaporising in its atmosphere. ►



▲ Software such as DeTeCt can analyse your capture files, looking for impact flashes – evidence of rare, meteoric events within Jupiter's atmosphere

PROJECT 2

Basic image measurement with WINJUPOS

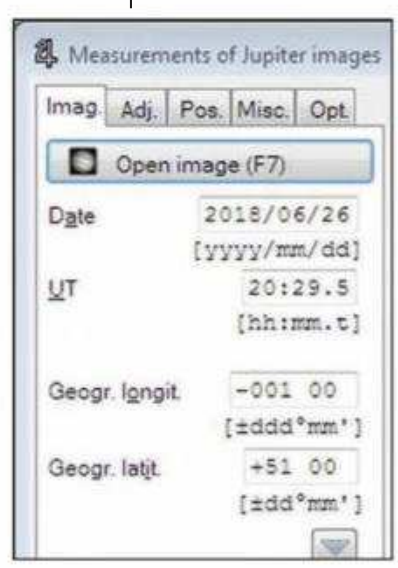
How to combine images of varying sizes from different sources into a measurable standard

WinJUPOS is the software equivalent of a Swiss army knife for planetary observing and imaging. It provides many functions, including the ability to measure, analyse and report on feature evolution and drift over time. One hurdle to overcome is normalising images to a common standard for comparison. For example, it's not uncommon to image over several nights with different camera orientations or even image scales. For comparative purposes WinJUPOS provides a function to bring images to a common measurement standard saved by the program as an Image Measurement Settings (.ims) file. This becomes the basis for other internal operations such as map generation and image de-rotation.

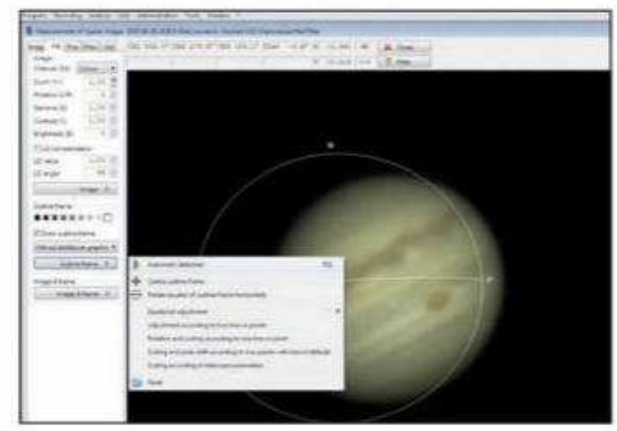
Step 1

Open WinJUPOS and from the Program menu option, click on Celestial Body and select Jupiter. Then from the Recording menu option select Image Measurement. From the Imag. tab in the window that appears, click Open image (F7).

Step 2

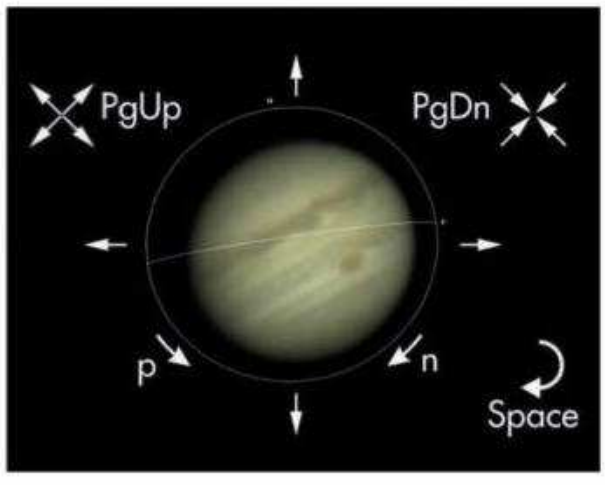


Some capture programs allow you to record movie sequences with filenames that are recognised by the WinJUPOS image measurement function, auto-populating the required inputs presented. Alternatively, enter the image values under the Imag. tab as required.



Step 3

Select the Adj. tab. Ensure the Draw outline frame box is ticked. Press F11 (or select Automatic detection of outline frame from the right-click menu) to align the frame to the image. Adjustments can be applied (step 4) if the frame is misaligned or upside down.



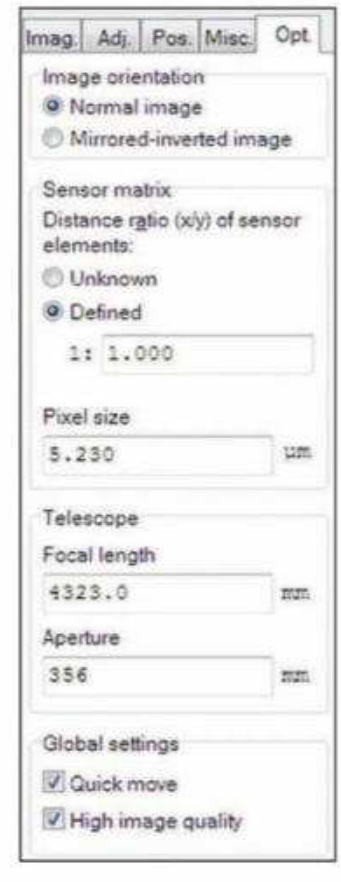
Step 4

Adjust the outline frame to match Jupiter's limb and orientation. Arrow keys move the outline; N rotates clockwise; P rotates counter-clockwise; PgUp enlarges; PgDn shrinks; and Space rotates by 180°. Use LD compensation to brighten the planet's limb if required.

ALL PICTURES: PETE LAWRENCE

Step 5

Record as an .ims file via the Imag. tab's Save button. Repeat for next (if any) capture images. It is recommended that once the outline frame has been set, it's left unadjusted for similar images from the same session.



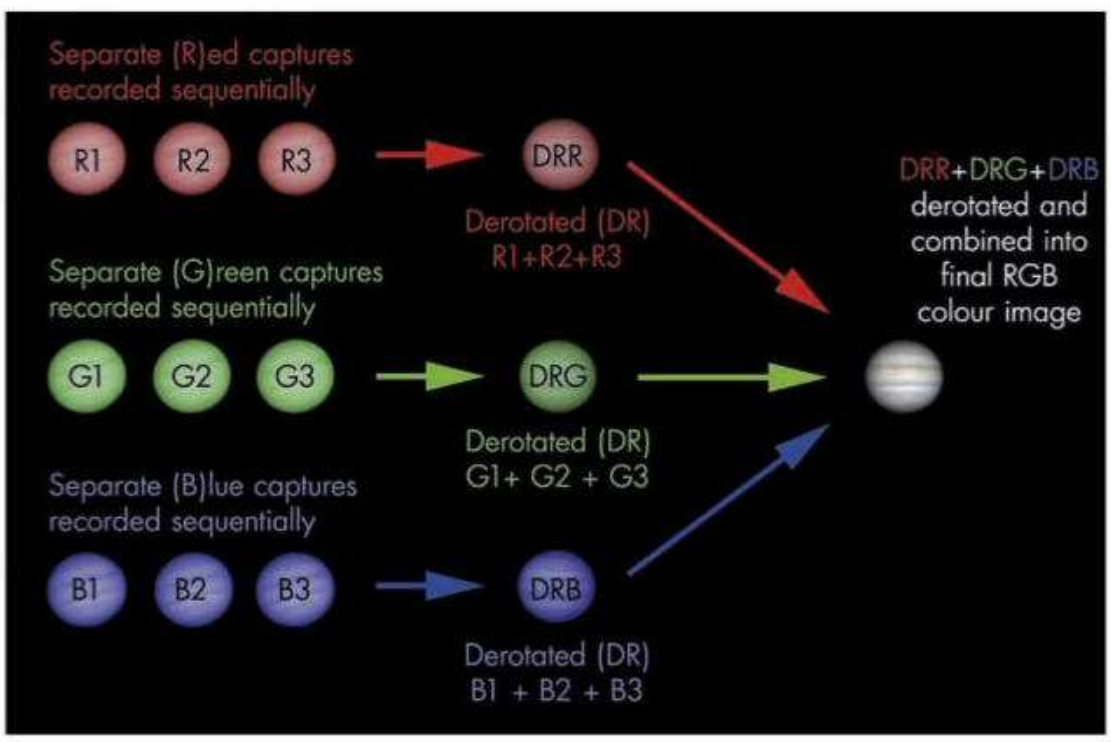
Step 6

The Opt. tab allows adjustment for non-standard sensors and image orientations. In addition, the focal length and aperture size can be defined to create an accurate scientific record of the capture stored in the saved .ims file.

PROJECT 3

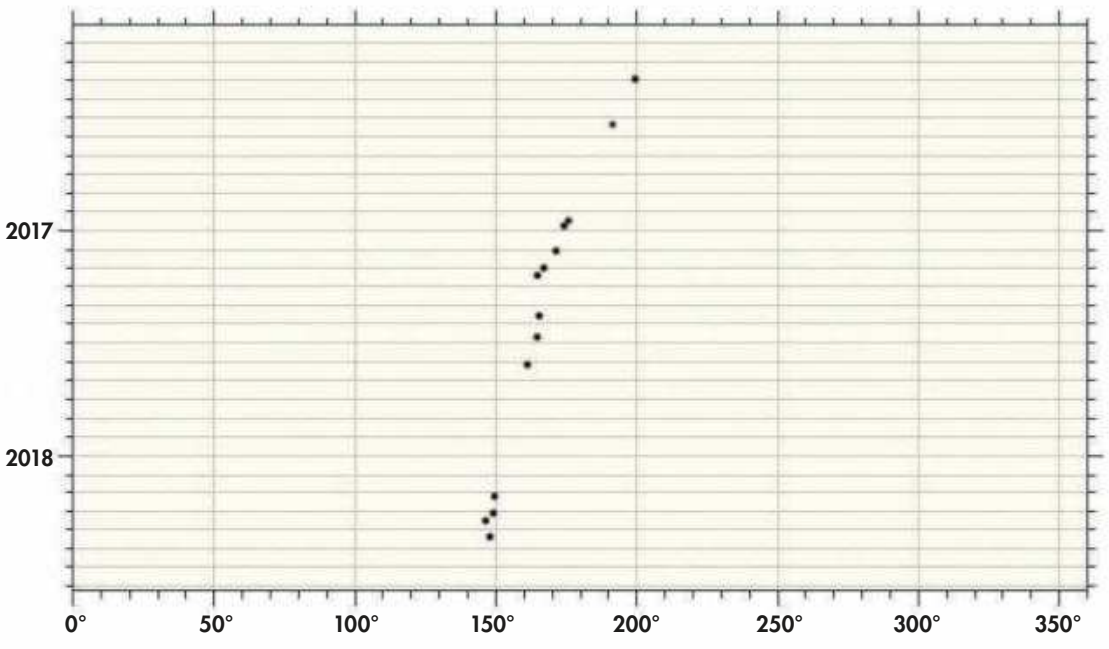
Mapping, derotating and measuring features using .IMS FILES

Once you've created your image measurement settings files, they have multiple uses in WinJUPOS

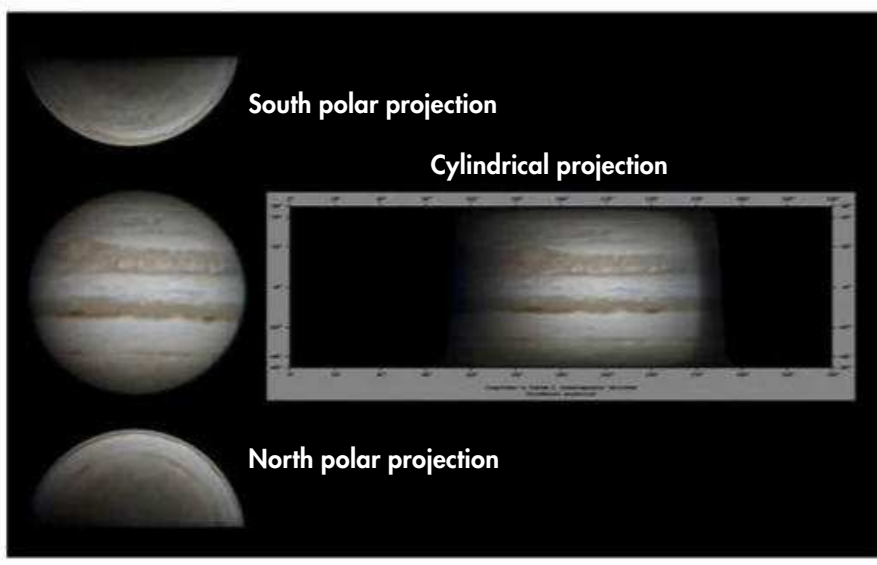


▲ **Image derotation sequence for three red, three green and three blue captures. If the three reds were captured over a four-minute window, and the same for the greens and blues, the final image would represents a 12-minute exposure**

Once an Image Measurement Settings (.ims) file has been created (see Project 2), additional options become available. Derotation (main menu Tools) allows sequential .ims files to be combined without concern for the accrued motion blur resulting from Jupiter's rotation. After derotating a set of reds for example, a similar process can be applied to the green and blue captures. The time stamp for the derotated results becomes the average time for the combined



▲ **WinJUPOS can be used to measure the position of features on Jupiter's disc and produce drift charts showing how the longitude of a feature changes over time**



▲ **Different .ims files from similar dates can be combined to create seamless, extended cylindrical maps**

.ims sets. Once completed, the derotated RGBs can be derotated and combined again to produce a sharp master colour image. The advantage with the cumulative longer exposure that derotation provides is a stronger signal-to-noise ratio and a cleaner end-result. The use of derotation effectively permits cumulative exposures of 10-20 minutes.

Another thing .ims files can be used for is measuring the position and size of different atmospheric features. When you load an existing .ims file via Recording Image Measurement the Misc. tab provides a quick facility to measure the size of extended features such as the Great Red Spot via the Measure Distance button.

Positional measurements are recorded by first defining a measurements file (MEA) via the Recording Measurements/New… option. A recommended format is to define a .mea file under a year folder using your name. From the image measurements window, select the Pos. tab. Here you can click on an image feature such as a light or dark spot, and save its position in the measurement file previously defined. This data can be analysed using WinJUPOS to create meaningful output such as longitudinal drift charts showing how features have moved in longitude over time. Monitoring features at different latitudes on the planet allows zonal drift speeds to be revealed.

Finally, .ims files are also useful for creating maps. The Analysis Map Computation… window allows you to process one or multiple .ims files, which may then be combined into a map using a variety of projection methods.

Help and tutorial files for all these processes are available via the WinJUPOS website.

Background image: Shutterstock

THE NORTHERN LIGHTS

With holiday companies releasing details of their latest aurora tours, now's the time to start thinking about booking your trip to see the Northern Lights.

Remember one thing...
never take your eyes off the skies, you never know when that spectacular display might appear.

SKILLS

Brush up on your astronomy prowess with our team of experts

The Guide

With **Jamie Carter**

10 common mistakes beginners make... *...and how to avoid them*

Sidestep these errors to become a seasoned observer

Sandra had always wondered why the stars were so small

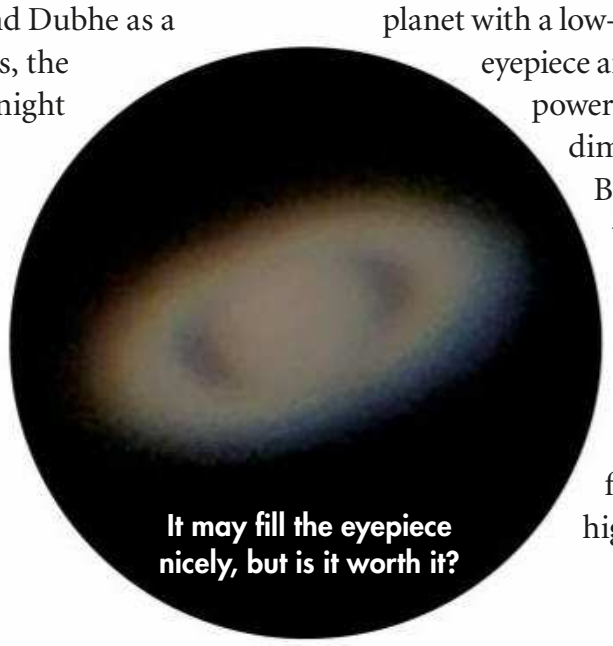
ISTOCK X 3, JAMIE CARTER

1 Stargazing too infrequently

It's difficult to dedicate time to standing in your back garden, but when you're learning your way around the night sky it's vitally important to go outside regularly and learn not only the major stars and constellations, but also the rhythm of the night sky. The positions of stars change constantly, rising in the east four minutes earlier each day to make space for new stars unknown to you. So try to go stargazing once a week, even if it's only for 20 minutes. The real art is cloud-dodging!

2 Expecting Polaris to be a bright star

Pick up any stargazing starter manual, and you will be told to look for Polaris, the North Star. You'll be told to find the Plough, and then use an imaginary line from its stars Merak and Dubhe as a pointer to locate Polaris, the star around which the night sky appears to revolve when viewed from the northern hemisphere. That makes Polaris special, but it's not a deep-sky object that brags about its importance – it's only the 48th brightest star in the night sky.



It may fill the eyepiece nicely, but is it worth it?

3 Using too much magnification

You want a close-up of the rings of Saturn through your telescope, so you find the planet with a low-magnification eyepiece and swap to a high-power one. The result? A dim, blurry image. Beginners often think that high power eyepieces are better for close-ups, but your telescope's aperture (how much light it gathers) is fixed. So if you use a high magnification all

Yes, a stargazing app can locate a star, but after using it your eyes won't be able to *see* the star

you're actually doing is diluting the light across a wider area. Less is more, and what power you can get away with depends on the quality of the eyepiece and atmospheric conditions. However, the rule of thumb for 'useful' magnification is allow 60x for every inch of aperture. For a typical 4-inch/100mm beginner's telescope, that's a 240x eyepiece.

4 Usng a smartphone to observe

Yes, there are some incredible planetarium apps, like Stellarium, Star Walk and Google Sky Map, that let you not only find objects in the night sky, but tell you all about them. To have that kind of information in your hand while you're outside stargazing is incredibly tempting – but resist it. Every time you look at your smartphone's white light LED screen, your night vision will be ruined. However, some planetarium apps do have a red light mode, which will lessen the damage if you also turn the screen's brightness all the way down.

5 Looking all over the sky for planets

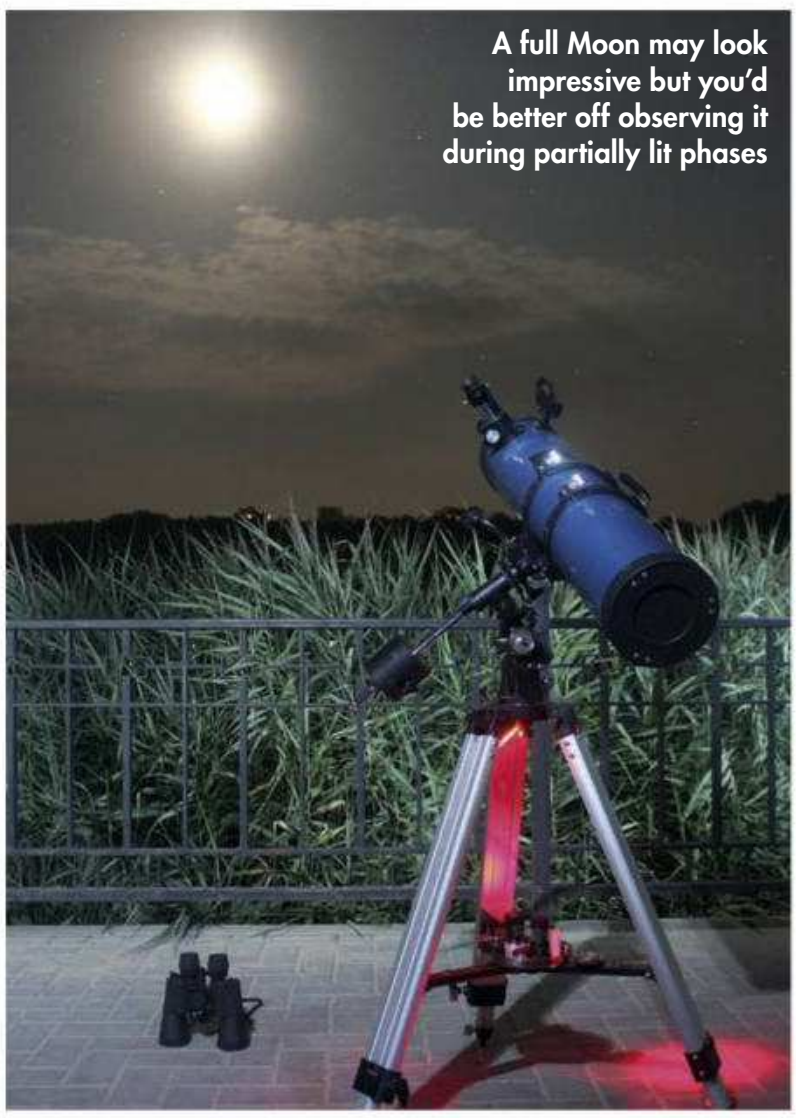
The Solar System is flat, with all of the planets, including our own, orbiting the Sun in more or less the same plane. That makes them pretty easy to spot. The Sun's apparent path through the daytime sky goes from the sunrise point on the eastern horizon over to the sunset point on the western horizon. This is called the ecliptic, and it's the only place where you'll find all of the planets (and also the Moon).

6 Buying a telescope too soon

The chance to look deep into the cosmos is tempting, but are you ready? Many a stargazer has purchased a telescope only for the fun to be replaced by frustration as they will struggle with aligning, aiming and focusing complex equipment rather than stargazing. So here's a plan; stargaze with your naked eyes for a year or two, then get some binoculars and use them for a while. Then visit your local astronomy club to get some hands-on experience of telescopes, and knowledgeable advice on what to buy.

7 Assuming it's easy to use a telescope

Have you ever been offered the chance to look through a large telescope and not had a clue what to do in the dark? Many amateurs completely forget that looking through a telescope takes skill and practice, so if you're at a star party, ask where the eyepiece is, because it differs depending on the design. Also ask where the focus knob is because once you're at the eyepiece that makes a huge difference. However, the most important thing is to take your time; you looked through the telescope for a reason, so don't be rushed, even if there is a queue.



A full Moon may look impressive but you'd be better off observing it during partially lit phases

8 Moon-watching at the wrong time

There's nothing better than a full Moon, surely? Watching our satellite rise every month is a real treat, but once it's about 10° above the horizon it is so bright that it's almost impossible to look at. Instead of Moon-watching at full Moon, start just after new Moon, when you can watch it gradually wax from a slim crescent to a full Moon. It will brighten slightly each night, but will be much easier to look at compared to when it's full. Pay special attention to the terminator line, which separates the Moon's lit side from the dark side; it's there that you'll see the shadows of craters, mountains and other details.

9 Not asking those 'stupid' questions

For a subject as complex as astronomy, there are no 'stupid' questions. When you first go to star party or any gathering of amateur astronomers, it's normal to presume that everyone there has a degree in astrophysics. They almost certainly do not. What they do have is years of learning, experience and a passion for the night sky they want to share. So go to a star party, introduce yourself as someone who's just started out or has lapsed for many years, and you'll be amazed at how much you can learn if you're not afraid to ask 'stupid' questions.

10 Relying too much on Go-To

Got a telescope with a Go-To computer that can find any object in the night sky? Many relatively experienced amateur astronomers rely on this system to locate objects in the night sky. However, if your goal all along was to have a working knowledge of the night sky and how it changes over the course of the year, relying only on the Go-To will not help you. So before you punch in the name of an object you want to study through a telescope, see if you can accurately point out where it is in the night sky. If you can't, you may be a proficient telescope-owner, but you're not a stargazer yet.

JAMIE CARTER is the author of A Stargazing Program for Beginners: A Pocket Field Guide

How to...

Capture star trails

With **Mary McIntyre**

Long exposures reveal the breathtaking circular motion of the night skies

▲ **You can capture the clockwise circular movement of stars around Polaris using long exposures**

ALL PICTURES: MARY MCINTYRE

Star trail photography is the art of capturing the apparent movement of the stars over a period of time using long exposures. Star trails produce stunning images in their own right, but if you add an interesting foreground when you shoot them, you end up with a really dramatic photograph.

The great thing about star trail photography is that is it easy to produce a fantastic result and you only need very basic equipment to do it. In fact, these days you can even do it with a smartphone. Here we're going to take you through how to shoot star trails using a DSLR camera.

Star trails are caused by Earth rotating on its axis. The stars in our northern hemisphere skies appear to move around the Pole Star (Polaris) which is almost perfectly lined up with the north celestial pole. The altitude of Polaris varies with latitude. If we were standing at the North Pole, it would be directly above the zenith. The further south you move from there the lower in the sky Polaris will be, so that at a latitude of 51°, Polaris will have an altitude of 51°, and so on.

Knowing the location of Polaris is important in star trail photography if you want to capture the stars moving in concentric rings around the celestial pole, which acts as a hub. The stars complete one full revolution in 23 hours 56 minutes and 4 seconds, so if we had 24 hours of darkness, the stars would form complete circles around Polaris, which itself hardly moves at all. The further away from Polaris you go, the further the stars move in a given period of time. Additionally, the star trails will be less curved and begin to flatten out as you move away from the celestial pole. If you are looking at the galactic equator, the star trails will be flat lines. Beyond that line, the stars will begin to curve in the opposite direction around the south celestial pole.

TOOLS AND **MATERIALS**

▶ DLSR camera, or other camera which has the ability to shoot exposures of 15 seconds or more with a continuous mode.

▶ Fully charged battery – or mains power adaptor if you're intending to shoot for several hours.

▶ Fixed tripod – this is one occasion when you absolutely don't want the camera mount to track.

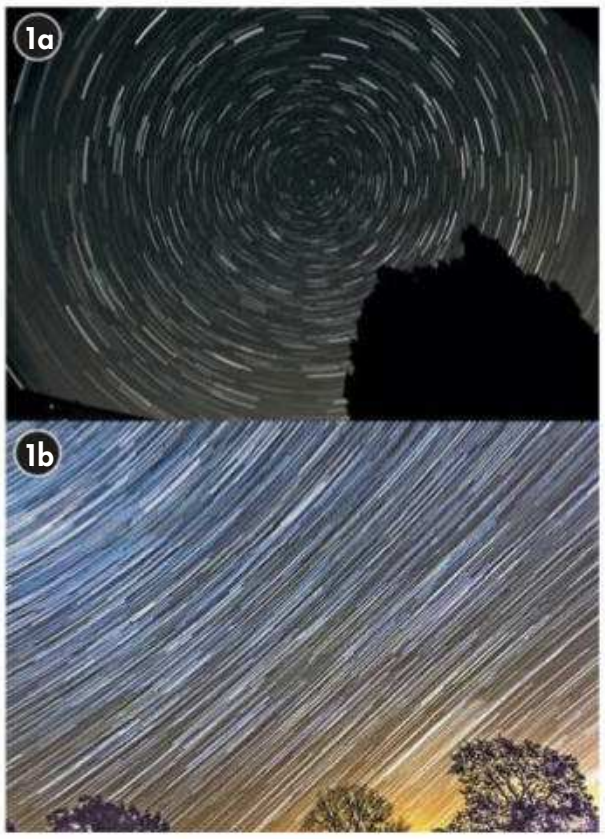
▶ A remote shutter release cable or an intervalometer.

▶ And old woollen sock and a couple of reusable pocket hand warmers to make a low-cost dew heater.

▶ Image stacking software.

Trail and error

The increasing speeds at which stars move the further they are from Polaris means that pointing a camera in different directions will give varying results. The further you point your camera away from Polaris, the longer and more dramatic your star trails will be. Figure 1 shows two different 45-minute long star trail exposures; figure 1a is pointing towards the north celestial pole and figure 1b is pointing at the celestial equator. For the main image of this article the camera was pointing southwest. This



▲ 1a is pointing towards the north celestial pole and 1b is pointing at the celestial equator

graduation in trail length is useful to keep in mind if you're planning to include a favourite landmark in your shot; don't just think about what angle makes the landmark look good, but what angle will reveal the most stunning star trails.

When shooting star trails, you may be tempted to set your camera to a low ISO and use the 'bulb' setting to open the shutter for one single, long exposure. There are several problems with this method, the biggest being that only the brightest stars will show up. Secondly, the background will totally wash out the stars you *have* picked up. Also, if a security light comes on your image will be drowned in its light, while low-flying aircraft will create ugly blurs.

A better method is to shoot a lot of shorter exposures and then use a freeware program such as StarStaX to stack them together, creating longer star trails from the many short trails captured. This way you'll be able to shoot with a higher ISO sensitivity setting and capture many more stars, plus the background light levels will be much darker. These programs have the added advantage of allowing you to remove a problem frame from the stack without leaving a gap in the trail.

Stacking software is very easy to use so don't be afraid to give it a try. Once you have stacked the images, only minimal processing is required to give you a great final result. For tips on processing, check out this issue's accompanying Image Processing article (on page 84).

MARY MCINTYRE is a dedicated astro imager based in Oxfordshire south

STEP BY STEP

STEP 1

To assemble the dew heater, place the sock around your lens, taking care that the fabric isn't overhanging the front. Activate the hand warmers and tuck them between the sock and the lens. This will prevent dew fogging the lens.

STEP 2

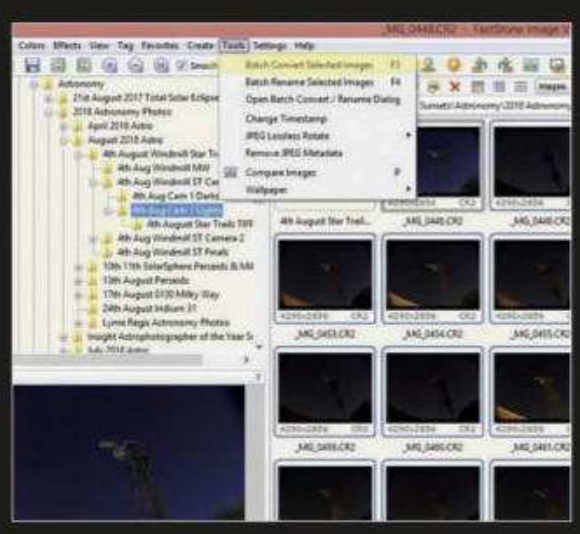
Set your camera to manual, turn off autofocus and set to f/3.5 or as low as your camera goes. Focus by pointing at a bright star (or the Moon, if it's up) and use live view at 10x. Set the exposure to 30s then do some test shots at ISO 800.

STEP 3

Choose your framing. Concentric rings? Polaris at the centre? Foreground objects will improve the shot, or consider having the tripod low to the ground to get a more interesting angle. Lock your tripod head and keep it anchored.

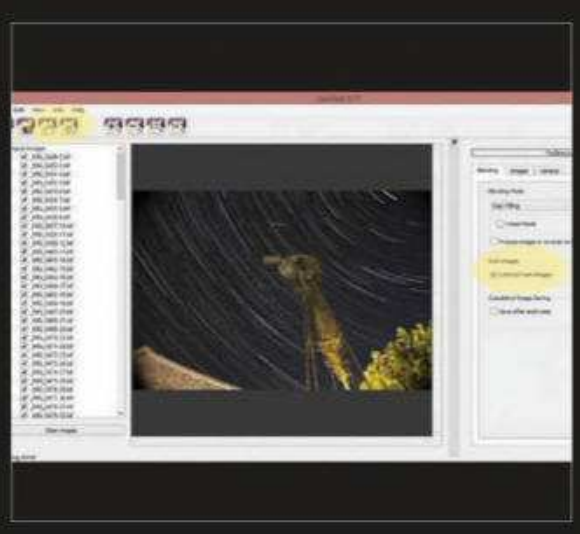
STEP 4

Lock off the remote shutter to keep it shooting continuously. For best results shoot in RAW, but JPEGs will do. Once finished, put the lens cap on, cover the viewfinder and – keeping all settings the same – shoot 10-15 dark calibration frames.



STEP 5

If you shot your images in RAW, batch convert your data to TIFFs using FastStone Image Viewer: open the images in the browser view, hit ctrl-A to select all, then click on Tools and batch convert the selected images.



STEP 6

Drag and drop your images into StarStaX and uncheck any problem frames. Open the dark frames, check Subtract Dark Images then hit the Stack button. Once the software has finished its routines, click on the Save icon to save your image.

Image PROCESSING

With
Mary McIntyre

Fine-tuning star trail images using FastStone

Some final cosmetic tweaks in an image editor can truly elevate your star trail photos

▲ **The final image, straightened, cropped and cleaned up to remove satellite and aeroplane trails**

Star trail images look very striking straight out of the stacking software. However, they can sometimes lack contrast and, if you've shot them in a light-polluted area, the chances are that your white balance will be pushed towards pink. Additionally, the colour saturation may need improving and there may be other flaws in the image caused by passing aircraft or telegraph wires. All of these issues are quick and easy to fix and will take an already dramatic star trail photograph to the next level.

In this article, we're using the free image editing software FastStone Image Viewer to make these final tweaks. The starting image was shot with a Canon EOS 1100D DSLR camera with an 18-55mm lens and a Japan Optics wide-angle lens attachment. 150 images and 15 dark frames were shot in RAW, batch converted into TIFFs then stacked in StarStaX.

To open the image in FastStone, right click on it and select 'Open with FastStone Image Viewer'. All the menus used here will appear when you move your cursor to the left of the screen. The first step is to straighten the image then crop it to remove vignetting from the lens attachment. From the left-hand list select the 'Rotation, Resize and Text' menu and click on 'Straighten'. Use the slider that appears to straighten the image; in this case we corrected the angle of the windmill. Click 'OK'.

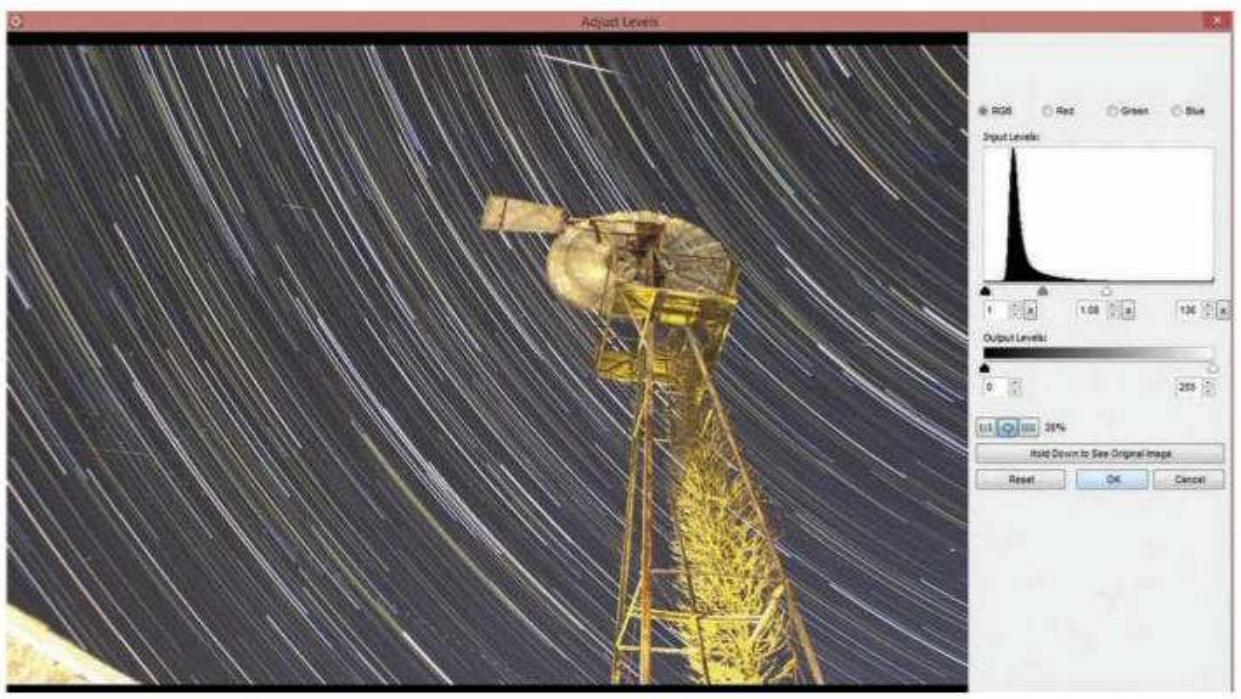
Cropping and framing

From the same menu, click on 'Crop Board'. Keeping to the same ratio that you shot the image in, position the cropping frame where you want the cropped area to be. Here we've opted to place the windmill on the left vertical grid line to adhere to the 'rule of thirds', while cropping out a shrub that suffered from motion blur. Click on 'Crop' when finished.

From the 'Colours' menu, click on 'Levels'. The histogram shows the peak

ALL PICTURES: MARY MCINTYRE

▲ Cropping removes a blurred shrub and allows the windmill to fulfil the 'rule of thirds'



▲ Use the right-hand slider under the Levels histogram to brighten up the background

where most of the data is. Drag the right-side marker to the left to brighten up the background and adjust the middle slider to attain the desired level of contrast. Be careful not to overexpose the brighter areas and be gentle with the contrast. Click 'OK' when you're happy.

Next, click on 'Adjust Lighting'. Using the sliders, adjust the highlights, shadows and contrast until the background is brighter but without losing too much contrast. Then adjust the colour saturation a small amount up or down to make sure the star colours are apparent without looking too garish. Click 'OK' when done.

Also from the 'Colours' menu, select 'Adjust Colours' and use the red, green and blue sliders to correct for sodium light pollution. If necessary you can change the hue and tweak the saturation again. A little goes a long way with these sliders so keep changes subtle. Click 'OK' when finished.

Even when you've included darks, your image may still suffer from noise. Luckily FastStone has an excellent noise reduction tool. From the 'Colours' menu, select 'Reduce Noise'. Drag the preview window around until you identify the noisiest part of the image. Drag the luminance slider up until you get a smoother background without losing detail; using the 'Detail' slider you can increase how much detail is preserved. Play with both sliders until you have a good balance between the two, then click 'OK'.

Send in the clones

Next you can make any necessary cosmetic adjustments such as eliminating aircraft trails, satellites and hot pixels not removed by the darks. This can be achieved using the 'Clone and Heal' function found in the 'Rotation, Resize and Text' menu.

The idea is that you replace a small affected patch of your image with a similar non-affected one nearby. Click on 'Clone and Heal' and make sure you have the 'Clone' button checked. Increase or decrease the size of the brush using your mouse scroll button, though normally it's best to use as small a selection as you can. Select an area close to the part you need to clone out (and obviously as similar as possible, just without the offending glitch), hold down the Control button on your keyboard and click the mouse on that area.

Now when you click over the problem section, it will be replaced by the area you cloned earlier. With star trails it is essential that the trails form a continuous straight line so take your time and get things lined up properly. Repeat this step anywhere on your image that it's needed.

Finally, if necessary, go back and tweak the levels once more before saving. To save your image, select 'Save as' from the 'File and Slideshow' menu. Now you're ready to wow friends and family with the gracefully arcing beauty of your final image.

MARY MCINTYRE *is a dedicated astro imager based in Oxfordshire*

▲ One of the best reasons for using FastStone is its excellent noise reduction tool

Alderney is the perfect location to discover the starry skies above. Set in the English Channel, the island is small and low-lying, blessed with pristine air and has little light pollution.

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Scope DOCTOR

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I have a Celestron NexStar 130 SLT with a 2x Barlow and a 9mm eyepiece, but my planetary photos still appear tiny in my 45MP DSLR camera. Do I need more magnification?

ANDY THOMAS

▲ The Celestron 93711 NexImage 5 is a specialised planetary imaging camera

WWW.THESECRETSTUDIO.NET, PAUL WHITFIELD

The Celestron NexStar 130 SLT is a Newtonian reflector with a 5-inch aperture, a focal ratio of f/5 and a focal length of 650mm, making it an excellent choice for general astronomy. With your 9mm eyepiece and 2x Barlow lens, you will achieve a magnification of 145x. The theoretical maximum magnification of your telescope is 250x. However, the reality is that in typical seeing conditions, the useful magnification is about 150x so you are already at the point where there would be no useful gain for planetary observing. For deep sky observing, apart from splitting binary stars, you would almost certainly enjoy better views with less magnification.

From the brief description of your DSLR camera, it appears that your sensor has 4.3µm pixels so the sampling rate is 1.36 arcseconds/pixel without the use of your 2x Barlow lens. No matter what camera you use, the planetary disk will always be the same physical size on the sensor for a given telescope. Using a planetary imager – for example the Celestron 93711 NexImage 5 which has 2.2µm pixels – the sampling rate would become 0.7 arcseconds/pixel so this would achieve a considerable improvement in resolution over your DSLR camera. You could also consider the Orion 52097 StarShoot 5MP Solar System Colour Camera or the Lumenera Lw575C 5MP enclosed colour camera.

Under average seeing conditions you could push your focal ratio to f/15 to increase object size on the sensor and this could be achieved with a 3x Barlow lens.

I'm looking to buy my first telescope. Would I be better off with a refractor or a reflector given that I will have to move it around a lot?

KATE LEWIS

▲ A large Newtonian reflector offers a wide aperture at the cost of regula collimation

There is a well-known maxim in astronomical circles: "The best telescope is the one you use the most." One that doesn't produce inspiring views or is difficult to set up and operate will end up sitting unused in a corner pretty quickly.

The largest aperture for your money will be a Newtonian reflector and as astronomy is all about capturing dim light, this is a serious consideration. However, you should bear in mind that reflectors require regular collimation to ensure that you get the best out of them whereas a refractor will remain collimated for years. That said, the collimation process is quickly learnt and fast to implement at the start of an observing session.

Mounting any telescope on a wobbly unwieldy mount will soon make you lose interest so you should allow for this when purchasing your first mount. That's the reason why a stable Dobsonian reflector is such a popular and recommended choice.

STEVE'S TOP TIP

What is backfocus?

Backfocus refers to the distance of the focal plane from the end of the eyepiece drawtube and it is critical that the telescope's focuser has sufficient travel both inwards and outwards to achieve focus with either an eyepiece or a camera.

Newtonian reflectors often suffer from insufficient inward focuser travel to allow a camera to reach focus, while refractors manufactured for portability with short optical tubes result in insufficient outward focuser travel. A star diagonal for eyepieces or an extension tube for cameras can resolve the issue in a refractor but resolving insufficient inward travel in a reflector is sometimes impossible without making big alterations to the telescope.

STEVE RICHARDS *is a keen astro imager and an astronomy equipment expert*

Email your queries to scopedoctor@skyatnightmagazine.com

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Bringing you the best in equipment and accessories each month, as reviewed by our team of astro experts

HOW WE RATE

Each product we review is rated for performance in five categories. Here's what the ratings mean:

★★★★★ Outstanding
★★★★★ Very good
★★★★★ Good
★★★★★ Average
★★★★★ Poor/Avoid

90

A metre-and-a-half long and built from steel, the Altair Wave 152 ED triplet refractor is a fine beast of a scope

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FIRST **LIGHT**

See an interactive 360° model of this scope at **www.skyatnightmagazine.com/AA152EDT**

Altair Wave
152 ED triplet refractor

WORDS: GARY PALMER

Size isn't everything, but this scope has the performance to back up its bulk

VITAL STATS

- **Price** £4,250
- **Optics** Air-spaced triplet
- **Aperture** 6-inch (152mm)
- **Focal length** 1,216mm, f/8
- **Focuser** 3.7-inch, CNC-machined rack-and-pinion
- **Extras** Tube rings, Losmandy plate, finder bracket
- **Weight** 15kg
- **Supplier** Altair Astro
- **Tel** 01263 731505
- **www.**altairastro.com

SKY SAYS...
This impressive-looking scope's excellent optics deliver some sharp, crystal-clear images

ALL PICTURES: WWW.THESECRETSTUDIO.NET

The launch of any new large triplet refractor is bound to grab the interest of astronomers from all areas of the hobby. With their three lens elements and multicoatings they deliver superior premium correction and razor-sharp stars, making them the deluxe choice when it comes to refractors. Altair Astro's new 6-inch (152mm) ED f/8 triplet telescope looks and feels like a luxury telescope even before you look through the eyepiece.

Upon opening the box, the first two things you notice are its size and its weight: it's a metre and a half long and the front lens cell is impressively hefty because it's built from steel rather than an alloy.

The lens is made from Hoya FCD100 glass and has a built-in, extending dew shield. Tube rings and a Losmandy plate are included. At the back end the telescope has a 3.7-inch, CNC-machined, rack-and-pinion focuser with a rotator and also a separate rotator for a camera. This contains a self-centring twist lock to hold cameras or diagonals. While this is a quick and easy method for attaching accessories, it did display a little movement. Altair has said there will be a traditional option of a compression ring and thumbscrews for people using heavy cameras and filter wheels.

Once the telescope was mounted it becomes evident that the balance point might cause a problem for people who use a tripod as there's a chance of this long telescope colliding with the legs. With the dew shield fully extended and imaging equipment attached the length of the telescope exceeds 1,500cm, so this could occur even with some large mounts; it is really best suited to a pier-based system.

Filtering for solar viewing

On a clear day, we set the telescope up for some solar viewing and imaging using a range of solar viewing eyepieces and a solar wedge. It's worth pointing out that any solar viewing eyepieces would need a front-mounted energy rejection filter owing to the aperture of the telescope. While there weren't many sunspots, the ones we did observe showed lots of detail around them and there was some nice granulation to be seen. Switching to a camera in the magnesium wavelength we were rewarded with ▸

Lens and cell

Using Hoya FCD100 glass the lens offers crisp and sharp optics for imaging and visual astronomy. The collimation screws are neatly hidden behind the dew shield. The field of view is impressively flat to almost the corners of the image and any star distortion is only seen on the largest of camera sensors. Imaging with an IMX 294 sensor showed the tiniest distortion in the corners of the image. The lens cell is a little different to most telescopes in that it is made of steel and not alloy. The problem with large lenses held in alloy is they can distort under rapid temperature changes. The manufacturer has changed the design a few times and this latest innovation is a good solution to an old problem that appears to have paid off; the optics were very stable throughout the review period and needed next to no focus adjustment during imaging sessions. The only downside is a little extra weight on the front of the telescope.

Finder shoe

The scope includes a finder shoe for attaching a finderscope. The shoe rotates with the focuser allowing the finderscope to be moved out of view of any guide equipment. For a lightweight imaging setup, the finder can also be used to mount small guiding cameras.

Tube rings

The AA152EDT features CNC-machined, lightweight aluminium tube rings that incorporate a carrying handle. The tube rings are felt-lined to stop damage to the telescope. The rings also have easy grips on top of them with smooth threads that make balancing the telescope easy.

Focuser

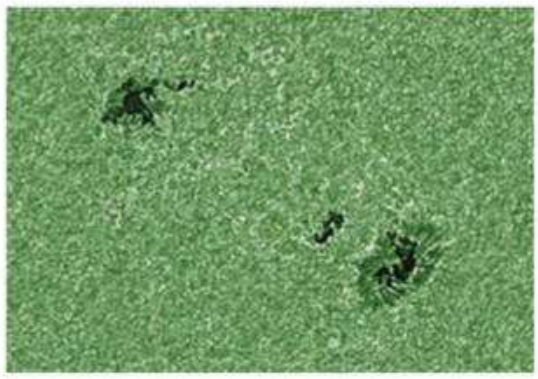
Focusing has been made effortless thanks to a high-quality, CNC-machined rack-and-pinion focuser accompanied by a micro focuser allowing for fine adjustments. The focuser can handle the heaviest of cameras and equipment with ease and can also be fully rotated, allowing the telescope to be mounted onto various equipment without the focus knobs getting in the way.

Losmandy plate

The Losmandy plate comes in anodised black and incorporates a 30mm centre-to-centre M6 hole spacing and a centre-slotted hole enabling multiple adjustment alignment of the tube rings. This allows for a firmer and more rigid mounting system, which is necessary when using heavier telescopes.

FIRST LIGHT

▲ Mars – 2,000 frames captured for each channel in FireCapture; 250 stacked in AS2 and processed in Photoshop



▲ Magnesium image – 1,000 frames captured in SharpCap; 250 stacked in AS2

▲ M31 dust lanes – 60x60", captured in SharpCap and processed in PixInsight

▼ The Moon – Altair Astro 183C Pro Tec camera; 200 frames captured in SharpCap; 50 stacked in AS2 and processed in Photoshop

SKY SAYS...
Now add these:

1. Altair 60mm RACI finderscope

2. iOptron CEM60 mount

3. Altair Premium prism diagonal

Dew shield

In average temperatures the built-in, retractable dew shield helps to keep invasive moisture down to a minimum. The inside of the shield is coated black to block stray light from entering the telescope. It fits snugly and firmly to the tube and is easily adjustable.

▸ some nice images showing plenty of detail in prominence and sunspots.

Our next target was the Moon on view in the daytime, and we were once again rewarded with pleasing views and images. The focuser on the telescope is a joy to use visually with your eye to the eyepiece; very smooth, it's easy to achieve fine adjustments. We could see that a lot of thought had been put into this area and it would rival some top-end manufacturers.

Planets have not been easy to observe this year but the dust storms on Mars had started to dissipate during the review period, so we could see and image some structural detail on the Red Planet and also capture some nice detail with a mono camera and filter wheel. Saturn produced nice clear detail around the Cassini Division and on one clear afternoon we managed to image Venus with a one-shot colour camera.

Moving to the deep sky was not without its struggles through the review period because of cloud and a bright Moon. Eventually setting up visually, we did get good views of comet 21P with nice tight stars in the eyepiece. Looking around at other targets such as star clusters and double stars, we were pleased with the views.

Currently Altair offers no dedicated flattener or reducer for deep-sky imaging but is looking into it. With lots of changes in the camera market it's not such a problem imaging at relatively long focal lengths these days so we set up the telescope with an 80mm guidescope and tried a few different cameras on deep-sky targets. Using a range of imaging times from 60 seconds to three minutes for different targets, all the images had nice detail for the conditions.

The Altair 152 EDT is well designed with some nice touches and good optics. If your budget allows it would be a good addition for any astronomer. S

Verdict

Build and design	★★★★½
Ease of use	★★★★½
Features	★★★★★
Imaging quality	★★★★★
Optics	★★★★★
OVERALL	★★★★★

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FIRST **LIGHT**

See an interactive 360° model of these binos at **www.skyatnightmagazine.com/helios16x80**

Helios Stellar II 16x80 binoculars

WORDS: STEPHEN TONKIN

For binocular newcomers, these are the prefect step up without breaking the bank

VITAL STATS

- **Price** £279
- **Optics:** Fully multi-coated
- **Aperture:** 80mm
- **Magnification:** 16x
- **Prisms:** BaK4
- **Angular field of view:** 4°
- **Focusing:** Individual eyepiece focus
- **Eye relief:** 20mm
- **Interpupillary distance:** 56-74mm
- **Weight:** 2.4kg
- **Supplier:** Optical Vision Ltd
- **www.**opticalvision.co.uk

For several decades now the Helios Stellar range has had a reputation for consistently producing good quality, mid-priced astronomical binoculars. That's why we were eagerly looking forward to this opportunity to try out the latest offering from the Stellar II range, the 16x80s.

SKY SAYS...
A significant improvement over most pairs of starter binoculars

The immediate impression is how robust they feel. They are covered in a synthetic, rubber-like armour, which gives a secure grip with or without gloves, even when they're damp with dew. The individual eyepiece focusing is smooth but could be slightly stiffer to prevent accidental refocusing, especially when you're folding down the eye cups. The knurled ring on each eyepiece makes them easy to focus with gloved fingers.

The central hinge is not only smooth but tight enough that it won't accidentally slip once you've set it where you want it, or when you're adjusting the focus on a tripod-mounted pair of binoculars. The plug-in objective covers are an excellent fit and won't come off accidentally so long as you make sure you've attached them properly. The eyepieces have a tetherable double rain guard-type cover that fits securely and doesn't limit the interpupillary distance when in place.

There is 10mm between the eyepieces at their closest, which should comfortably accommodate most people's noses, and the pliant, rubber eye-cups make the binoculars comfortable to use. The objective lenses are recessed 14mm into their barrels, giving good protection against accidental touching, but insufficient for dew protection. When you look through them, the images from each side immediately merge into one throughout a range of interpupillary distances, indicating that the collimation is spot on.

With fully-corrected vision, the eyepiece dioptres were close to zero when we focused to infinity, suggesting they've been set properly. There is a huge amount of adjustment available either side of this, so the binoculars can easily be used without spectacles by people with acute long- or short-sightedness.

Baffling lack of glare

Despite the absence of any baffles inside the objective tubes control of stray light is good, with only a small amount of glare when the Moon was ▸

Very bright images

What immediately struck us the first time we tried these binoculars is how bright many of the usual 'faint fuzzy blobs' seemed. Some of this is down to the very good anti-reflective coatings, but it is mostly thanks to the 5mm exit pupil resulting from 16x magnification with 80mm aperture. 5mm is only slightly less than the diameter of a typical adult's pupils, so it produces a near-maximum image brightness on your retina. This makes smaller, fainter objects like M51 and M81 very easy to locate. On a Moonless night under a suburban sky, the nearer edge of the Andromeda Galaxy, M31, had a more abrupt edge because of its dust lane. The Triangulum Galaxy, M33, showed a mottled effect that hinted at its spiral structure and, despite being at low altitude, the Pinwheel Galaxy, M101, was unusually distinct. Comet 21/P Giacobini-Zinner, which was in Cassiopeia at the time, was obviously non-stellar and, with averted vision, even showed hints of a tail.

Effective anti-reflective coatings

When we shone a bright light into the objective lens, only a small amount of light reflected from its surface, confirming the effectiveness of the anti-reflective coatings. Helios specifies a light throughput of 85 per cent, which is what you would expect for binoculars of this quality.

Central mounting bar

The central mounting bar adds rigidity to the objective barrels. The sliding mounting post, which allows you to achieve optimal balance, is threaded to ⅜-inch, with a ¼-inch adaptor provided so that it fits both standard sizes of tripod head screw.

Waterproof and nitrogen-filled

Rather than just specifying these binoculars as 'waterproof' Helios has rated them as IPX7, which means they will keep water out when totally immersed to a depth of 1m or for 30 minutes. Meanwhile, the nitrogen filling will prevent any internal corrosion by oxidation.

FIRST LIGHT

Good eye relief

If you need to observe while wearing spectacles, the rubber eye cups fold down easily. The eye lenses are recessed slightly for protection, but there is enough of the specified 20mm eye relief available to enable the entire field of view to be visible with spectacles.

SKY SAYS...
Now add these:

1. Fotomate VT-680-222R tripod

2. Sky-Watcher dual LED flashlight

3. Sky-Watcher anti-tip observing chair

▸ just outside the edge of the field of view, and none at all with first magnitude stars in the same position.

We tested the Stellar IIs under a variety of sky conditions, mounted on a sturdy photographic tripod with a fluid video head. Stars consistently came to a good focus over the central 70 per cent of the field of view. We noticed a small amount of off-axis chromatic aberration on the Moon's terminator and limb, but the on-axis colour correction is good. This aids the colour rendition, which is excellent. The different hues of Alderamin (Alpha (α) Cephei) and Zeta (ζ), Delta (δ) and Mu (μ) Cephei were immediately obvious, and the contrasting gold and sapphire of Albireo (Beta (β) Cygni) was almost vibrant. We could easily split Albireo into its two components and, despite some field curvature, could see that the star was a double over the central 85 per cent of the field of view.

Deep-sky excellence

This was all very impressive, but where these binoculars really excelled was on open clusters and extended deep-sky objects such as galaxies and bright nebulae. The Pleiades leapt out at us, its collection of hot blue-white stars blazing like diamonds under a spotlight; both the southern Milky Way and the Cassiopeia region were filled with knots of stars and – even under suburban skies – the North America Nebula (NGC 7000) was obvious as a brightening of the sky background. The contrast is very good and, when the constellation Cygnus and Aquila were at their highest in the late summer sky, their dark nebulae gave a 3D effect to the Milky Way.

The Helios Stellar II 16x80s are a significant step up from typical 'starter' binoculars, so if you've been bitten by the binocular astronomy bug and want something that will show you considerably more without stretching your finances as much as premium binoculars will do this would be an excellent choice. S

Good quality carry-case

The military-style, woven nylon case feels satisfyingly robust and has enough padding to offer good protection to your investment. It seals with a side-release buckle, and the same device is used to attach the webbing shoulder strap. It has very substantial belt loops.

Verdict

Build and design	★★★★½
Ease of use	★★★★½
Features	★★★★½
Field of view	★★★★½
Optics	★★★★½
OVERALL	★★★★★

TRIED & **TESTED**

See an interactive 360° model of this mount at **www.skyatnightmagazine.com/TTS160**

Panther TTS-160 tracking mount

WORDS: PETE LAWRENCE

We review well-established equipment that has stood the test of time

VITAL STATS

- **Price** £4,820 for the standard TTS-160 altaz setup with pier and 4kg weights, plus £140 shipping; £960 for optional rOTAtor
- **Load capacity** 22kg
- **Dimensions** 1,303mm without pier extension; 1,533mm with extension
- **Features** Fast setup, no polar alignment, no levelling, no meridian flip
- **Optional extras** rOTAtor field-derotator, side-saddles (Vixen or Losmandy), 8kg counterweights
- **Supplier** Peak 2 Valley Instruments
- **Tel** 07957 242235
- **www.**peak2valley instruments.co.uk

WWW.THESECRETSTUDIO.NET X 4, CHRIS HOWEY

The Panther TTS-160 – or the Track the Stars Panther 160 to give it its full name – is an unusual, eye-catching mount. It's extremely well engineered and offers portability, quick set up, excellent tracking and accurate Go-To capabilities. Its design also removes the need for a meridian flip during long-exposure astrophotography sessions.

The TTS-160 is modular, its various sections arriving packaged in neoprene travel bags. Our sections included a folding pier base, a pier extension with adaptor and the mount head. The bottom section has an ingenious fold-out tripod inside the cylindrical pier body. The legs spread out at 120° intervals and are hand tightened to the pier using three tension rods.

Assembly is really quick and easy, which was really handy when an unexpected cloud window appeared one evening when we wanted to image comet 21P/Giacobini-Zinner. The comet was awkwardly positioned behind a building so portability was essential. As the cloud gap was small, we opted to use the TTS-160. With no requirement to level the mount or polar align, we were up and running in under 10 minutes.

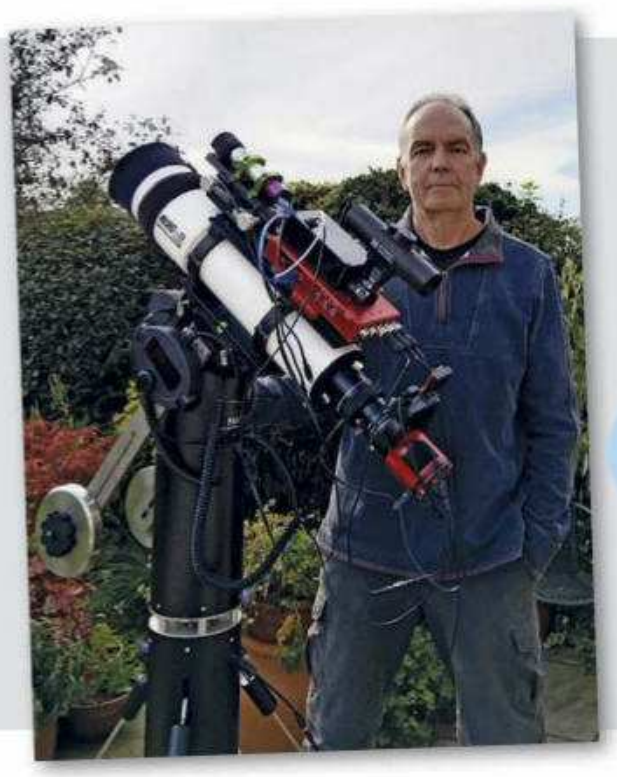
SKY SAYS...
Design is function with this striking, game-changing mount, the first version of which came out in 2007

The TTS-160's central, domed pier has a pivot on either side. A two-arm frame is attached to the pivots with the telescope clamp on top. The mount's counterweights each have projecting flanged pins that slide into slots on each arm. The top clamp is Losmandy-style with adaptors available for Synta/Vixen dovetails. The frame's position is lockable so you can attach a telescope onto what's essentially a horizontal saddle. We can't stress enough how good this arrangement is; lifting our test 10-inch LX200 optical tube onto the saddle was really easy. Two additional saddles can be attached to the side pivots if required, bringing the scope count up to three.

Switch on, set up

The TTS-160 is an altaz mount and tracking objects across the sky is achieved by the mount's on-board computer simulating equatorial motion. This requires a 12V supply. Unnervingly, there's no switch; you turn it on and off simply inserting or pulling out the lead.

A quick set-up routine is required and typically involves aligning the mount to one, two or three ▸



Owner's observations

Name Chris Howey
Location Cambridge Village, Gloucestershire
Equipment The Panther TTS-160 with TTS rOTAtor
Owner since February 2013

I'm certain I would not have achieved my dream of astro imaging without this mount. Five years on it continues to operate perfectly. There are no meridian flips with it, no polar alignment and no levelling needed, I can set up in 10 minutes and be imaging in 25. The dedicated rOTAtor rotates the whole OTA with high accuracy and the user-friendly hand controller allows me to zip through the menus. I image in narrowband and for the first three years I used 15 or 20 minute subs with great success. Now, using my Borg 125SD with super reducer (f/3.9) and a ZWO ASI1600MM, I can bag 40 two-minute subs or more before rewinding the rOTAtor, allowing me to achieve a bi-colour or Hubble palette image in one session. Additionally, I have a PrimaLuce EAGLE running SGPro and PHD2 on my rig. The Panther supports Meade LX drivers allowing me to use SGPro to plate solve and have the mount centre itself on target. It all packs into the supplied bags and, in my opinion, it is the ultimate portable mount.

Handpad

The elliptical handpad uses a four-line display viewed through a removable red filter. Three rotary-click dials let you scroll and select menu items as well as control the mount's slewing. The handpad attaches to the mount magnetically leading to a minor irritation – the connector cable tends to rotate the handpad upside down.

Counterweights

The TTS-160 has a 22kg capacity with 2x4kg weights for balancing intermediate weight instruments. 8kg weights are also available separately. The weights have flanged pins which slide along slots in the mount's frame arms. A rotary-knob locks the weights in the desired position. Using an optional side-saddle, a small scope can be used without counterweights.

Interface ports

Five connection ports are provided. One connects to an ASCOM enabled PC, one is used for auto-guiding and one for auxiliary equipment such as the rOTAtor. Another connects the handpad with the final one being used for 12V power. The field-derotating rOTAtor requires 12V. A power-splitter cable divides power to the mount and the rOTAtor.

Sectioned design

The base section incorporates folding tripod legs which are hand-tensioned to the lower pier. An optional pier extension gives extra height if required. Thumb cogs screw sections together without the use of additional tools. However, a warning: it's easy to get carried away while spinning the cogs, giving your thumb and fingers a slight pinch.

TRIED & **TESTED**

SKY SAYS...
Now add these:

1. Side-saddles (Vixen or Losmandy) for mounting additional telescopes

2. Extra 8kg counterweights

3. 12V power supply (cigarette lighter-style plug)

▸ bright stars. After two-star alignment, we found the TTS-160 would place selected Go-To targets more-or-less in the centre of field every time. Tracking accuracy was good too. With a high magnification view of M27, the Dumbbell Nebula, the object remained centred in our eyepiece for several hours.

An issue you can't ignore when using altaz platforms for long-exposure imaging is field-rotation – the way the imaging field rotates about its centre over time. The speed of this effect also varies with a target's location in the sky. Field rotation can be addressed by using a field derotator. The TTS-160 has an optional Panther telescope rOTAtor to perform this job, and we had one on loan for the review. The rOTAtor fits into the mount's top Losmandy saddle, presenting the same size of saddle for your telescope to attach to. A connector lead interfaces the rOTAtor with the mount, the hand pad providing operational control. The rOTAtor was simple to use and worked extremely well, allowing us to take extended exposures.

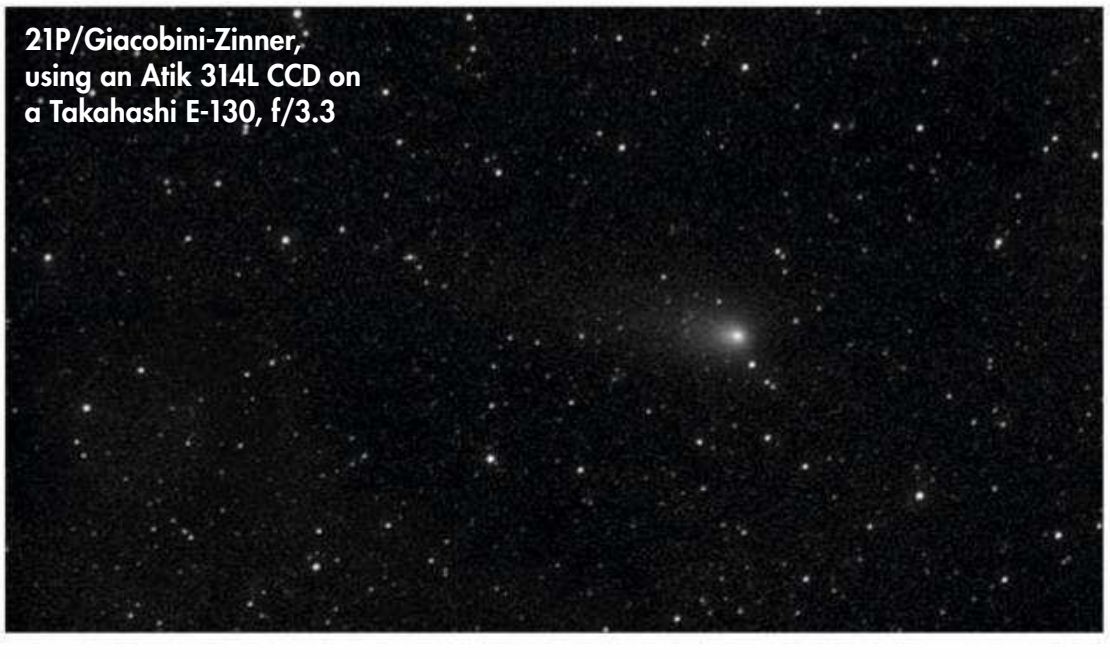
An oval-shaped handset provides the interface for mount operations. Three rotate and click wheels provide access to the internal menus as well as controlling variable rate slewing in altitude and azimuth. It takes time to get used to the handpad and in some instances we found the menu navigation a bit cumbersome. Should you require it or want to, you can also connect the mount to a PC for external control via ASCOM-enabled applications.

Despite its unconventional appearance, the TTS-160 delivers the goods and is a delight to use. It's not cheap but for your money you get a stable, accurate mount that's quick and easy to set up. You also get something that's almost certainly going to turn a few heads. S

rOTAtor (field derotator)

The optional rOTAtor unit is essential if you intend to do long-exposure astrophotography. It connects via an aux port to the mount. Its operation is controlled via the handpad. The unit allows one to three hours of imaging, depending on the target's location in the sky. After this time, it simply resets itself for the next run.

▼ The Dumbbell Nebula, M27, using a Canon 6D DSLR on a Meade LX200, f/10, 60s exposure



21P/Giacobini-Zinner, using an Atik 314L CCD on a Takahashi E-130, f/3.3

Verdict

Assembly	★★★★½
Build and design	★★★★½
Ease of use	★★★★½
Go-To accuracy	★★★★½
Stability	★★★★½
OVERALL	★★★★★

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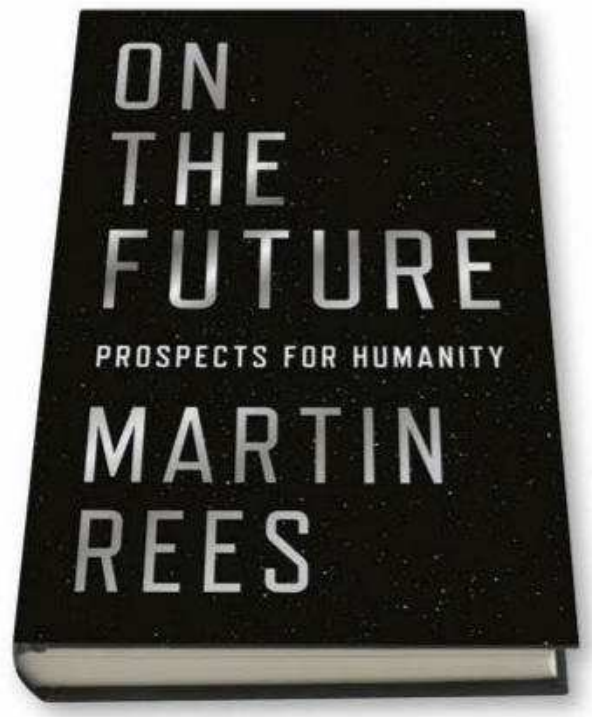
New astronomy and space titles reviewed

RATINGS

★★★★★ Outstanding
★★★★☆ Good
★★★☆☆ Average
★★☆☆☆ Poor
★☆☆☆☆ Avoid

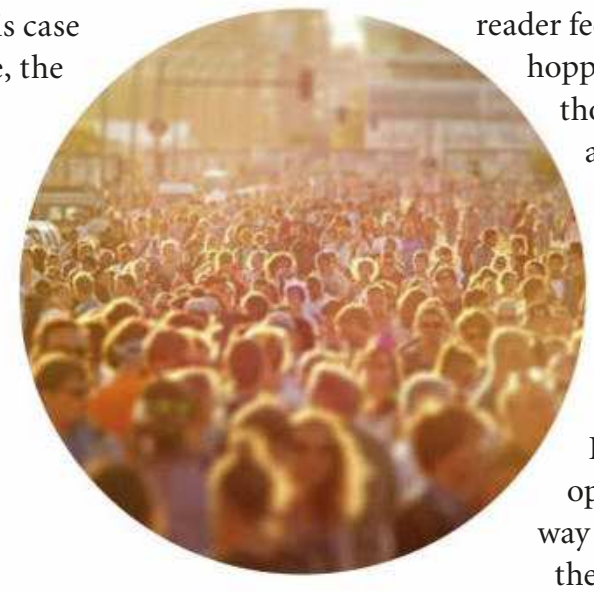
On the Future

Martin Rees
Princeton
£14.99 ● HB



The 22nd century is not so far away in the grand scheme of things. Taking into account the pace of current development, *On the Future* sees the incumbent Astronomer Royal, Professor Martin Rees, discuss the future challenges and opportunities that await the next generation. "How can they ensure that ever more powerful technologies can open up a benign future without threatening catastrophic downsides?" he ponders.

As a scientist, citizen and member of the human species, Rees talks about the concerns we face in a world of growing population, increased demands and limited resources, but argues that we have the ability to make wise choices. Although science in this case plays an important role, the major social challenges discussed in the book are shown to be matters that relate to all of us, requiring decisions that shouldn't only be made by scientists. That's why Rees provides an overview of the challenges and achievements in fields like energy, health, food, the environment, robotics and space in a broad and inspiring way for the general public, adding that "to grasp the key ideas isn't so difficult. Most of us appreciate music even if we can't compose it, or even perform it. Likewise, the key ideas of science can be accessed and enjoyed by almost everyone."



Social challenges like overpopulation cannot be solved by science alone

Rees writes about the complicated social challenges that should be discussed by people with different perspectives and levels of understanding. He looks at our present and future from different angles like nuclear energy, gene-editing technologies, space exploration and even the origins of life. The rapid-fire way he deals with these subjects makes the reader feel like they're hopping on a carousel of thoughts and gives us a rich overview, but perhaps more time could be spent on each topic for deeper reflection.

Nevertheless, in *On the Future* Rees shows us an optimistic yet realistic way of contemplating the what is to come, as long as we broaden our thinking and realise that we're all on this crowded planet together. As the author puts it: "We need to think globally, rationally and long term – empowered by 21st century technology, but guided by values that science itself can't provide."

★★★★☆

SANDRA KROPA is a science journalist and writer

ISTOCK

TWO MINUTES WITH
Martin Rees

What are humanity's biggest challenges?
We need to be concerned about the environment and move as quickly as we can to a low-carbon economy. This would best be done by accelerating research into clean energy so that the costs come down. Then countries like India, which need more energy and resources, will be able to leapfrog directly to clean energy and not build coal-fired power stations.

Do you think we should continue looking for extraterrestrial intelligence?
It's worth it for a chance of finding evidence of something manifestly artificial in the Universe in our lifetime. Currently it's all privately funded, which I feel is fully justified, but if you asked people coming out of a science fiction movie whether they'd be happy for some of the tax revenues from that movie to be hypothecated for the search for extraterrestrial intelligence, I think many would say yes. So I think it's reasonable for some public-funded projects to be aimed at this goal.

Are we entering a new epoch in our understanding of the Universe?
What has happened in astronomy is fascinating. When I started it was exciting because we had the first evidence of the Big Bang, black holes and neutron stars. But the pace has been just as high in the last few years with exoplanets, dark matter and the detection of gravitational waves. I think for young people thinking of a career in science, the prospects in astronomy are extremely bright.

LORD MARTIN REES is Astronomer Royal and Director of the Institute of Astronomy at the University of Cambridge

Wally Funk's Race for Space

BOOK OF THE MONTH

Sue Nelson
The Westbourne Press
£14.99 ● HB

Since 1961 Mary Wallace 'Wally' Funk has had the 'right stuff' to make the journey into space. She was among the first group of American pilots to pass the Mercury 13 programme, which tested women under the same conditions as NASA astronauts. But just one week before the final phase of testing, as a result of politics and prejudice, the programme was abruptly cancelled.

Undeterred, Funk devoted the rest of her life to getting to space. She's almost 80 now and there are no signs of the veteran aviator letting up. In this book Funk and author Sue Nelson go on the road together to visit such places as NASA, ESA and Virgin Galactic's Spaceport. We learn about their time together and their shared respect for all women who have defied the odds and lived life by their own rules.

The narrative flows wonderfully under Nelson's light and witty style. Funk's energy, single-mindedness and bloody-minded determination is often trying for Nelson as her travel companion, and the two clash over simple things, much to the amusement of the reader. The book points out that these characteristics are Funk's greatest strength.

Nelson's desire for Funk to still make it into space is apparent, and she pleads the case well, as a friend as well as a journalist. But is it too late?

"I wish I was born 20 years later," Funk admits. "Now I can't do anything but support space or lecture in schools about STEM. But honey, I wouldn't change my life for one minute."

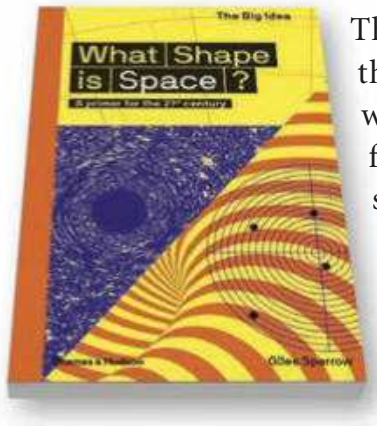
This is a truly inspiring book about friendship, women's place in the history of aviation and space and the cost of a dream.

★★★★★

NIAMH SHAW *is an engineer, lecturer and science communicator*

What Shape is Space?

Giles Sparrow
Thames & Hudson
£12.95 ● PB



They say that space is the final frontier, but where does the final frontier end? Does space have a limit, or does it stretch beyond the limits of our imaginations and towards the infinite? *What Shape is Space?* boldly endeavours to investigate these questions.

At first glance the book's layout appears to mirror the complexities of the questions it addresses. The text is presented in a dizzying array of font sizes and scattered paragraphs, but there is method in the typographical madness. The prose is actually presented in a hierarchical manner, with the information most key to understanding the overall concept presented in the largest fonts.

The book is broken down into four key topics that explore the evidence for an expanding and infinite Universe; the rate of the cosmos's expansion; the shape of the Universe; and, finally, the possibility of an infinite multiverse and how each possible shape affects our own Universe's eventual fate.

Sparrow's prose is engaging and, for the most part, accessible to those with some prior grounding in the subject, although as you delve deeper into the diminishing text hierarchy the complexity does increase.

The radical layout may prove to be too eclectic for some readers, and, while the format works in some respects, many of the illustrations and visualisations are relegated to the margins as they find themselves fighting a losing battle with the book's multiverse of fonts.

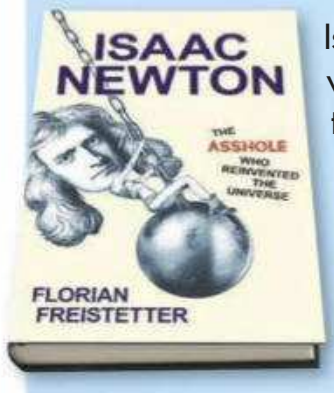
Putting the somewhat divisive design aside, there is a great deal to recommend about Sparrow's book for those wanting an approachable primer to this hugely complex question.

★★★★☆

BEN GILLILAND *is a science writer, graphic journalist, illustrator and author*

Isaac Newton: The Asshole Who Reinvented the Universe

Florian Freistetter
Prometheus Books
£18.55 ● HB



Isaac Newton was a great thinker of scientific ideas. As a human being, however, he left much to be desired. There are many books on Newton. Few, however, are as outspoken and to the point on his considerable character flaws as this one. The directness is refreshing.

The book tells the story of Newton's life and work with a focus on what made him (to quote the author) an 'asshole'. We see him steal data from fellow astronomer John Flamsteed, refuse to acknowledge other people's input into his work and feuding with pretty much everyone. Each chapter ends by imagining how this kind of behaviour would serve him in the modern scientific world.

The stories, all engagingly written, bring Newton's personality to life. Through his own words we get a real sense of his utter unpleasantness. The science is explained well and succinctly, as is much of the historical context for each story.

Less satisfying, I found, was the lack of insight into how these traits developed. The chapter endings, too, are problematic, with modern scientific processes feeling overly idealised in contrast to Newton's flaws.

The book's conclusion calls for us to see Newton as "an asshole" but also recognise him as a genius. Having read this book, I wonder if the two – genius and contemptibility – aren't more connected.

★★★☆☆

EMILY WINTERBURN is the author of *The Stargazer's Guide: How to Read our Night Sky*

Gear

Elizabeth Pearson rounds up the latest astronomical accessories

1 Explore Scientific 3x focal extender

Price £151 • **Supplier** Telescope House
01342 837098 • www.telescopehouse.com

Triple the focal length of your telescope and increase your magnification with this handy extender. High build quality ensures sharpness.

2 Lunt Mini SUNoculars

Price £26.95 • **Supplier** Harrison Telescopes
01322 403407 • www.harrisontelescopes.co.uk

Take a safe look at the Sun using these 6x30 'SUNoculars'. Their small size makes them perfect for travel, allowing you to keep watch for sunspots from across the globe.

3 Polar Gear lunch bowl

Price £9.90 • **Supplier** Online Kitchenwear
www.onlinekitchenware.co.uk

In the middle of a cold observing session, there's nothing like a hot snack to warm you up. This insulated lunch box keeps food piping hot to help keep you going.

4 Astro basic Moon and colour filters

Price £10 • **Supplier** Northern Optics
shop.nothernoptics.co.uk

These no-nonsense filters have a sturdy design and a low price tag, making them ideal for budding astronomers getting started in planetary and lunar observing.

5 Science Museum Floating Moon

Price £14 • **Supplier** Science Museum
020 7942 4000 • shop.sciencemuseum.org.uk

Keep the Moon within reach with this levitating globe, kept aloft by magnets.

6 Baader Microstage II digiscoping adaptor

Price £31 • **Supplier** Tring Astro
01442 822997 • www.tringastro.co.uk

This adaptor creates a stable platform for taking pictures afocally through your eyepiece with a digital camera. Then use the swing arm to move the camera out of the way and observe through the eyepiece.

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WHAT I REALLY WANT TO KNOW IS...
Why is the distant Universe opaque?

George Becker is investigating why a patch of the Universe lets through barely any ultraviolet light

INTERVIEWED BY ELIZABETH PEARSON

Most of the matter in the Universe is in deep space. When we think of a deep picture of the Universe we think of galaxies, but that's not actually where you'll find most of the stuff in the Universe. Instead, most of it is stored in an intergalactic network of filaments that connects the galaxies.

Most of the stuff in these filaments is hydrogen gas and nowadays most of it is ionised: electrons have been separated from protons. Ionised gas does not absorb ultraviolet (UV) light so the Universe today is pretty transparent to UV light.

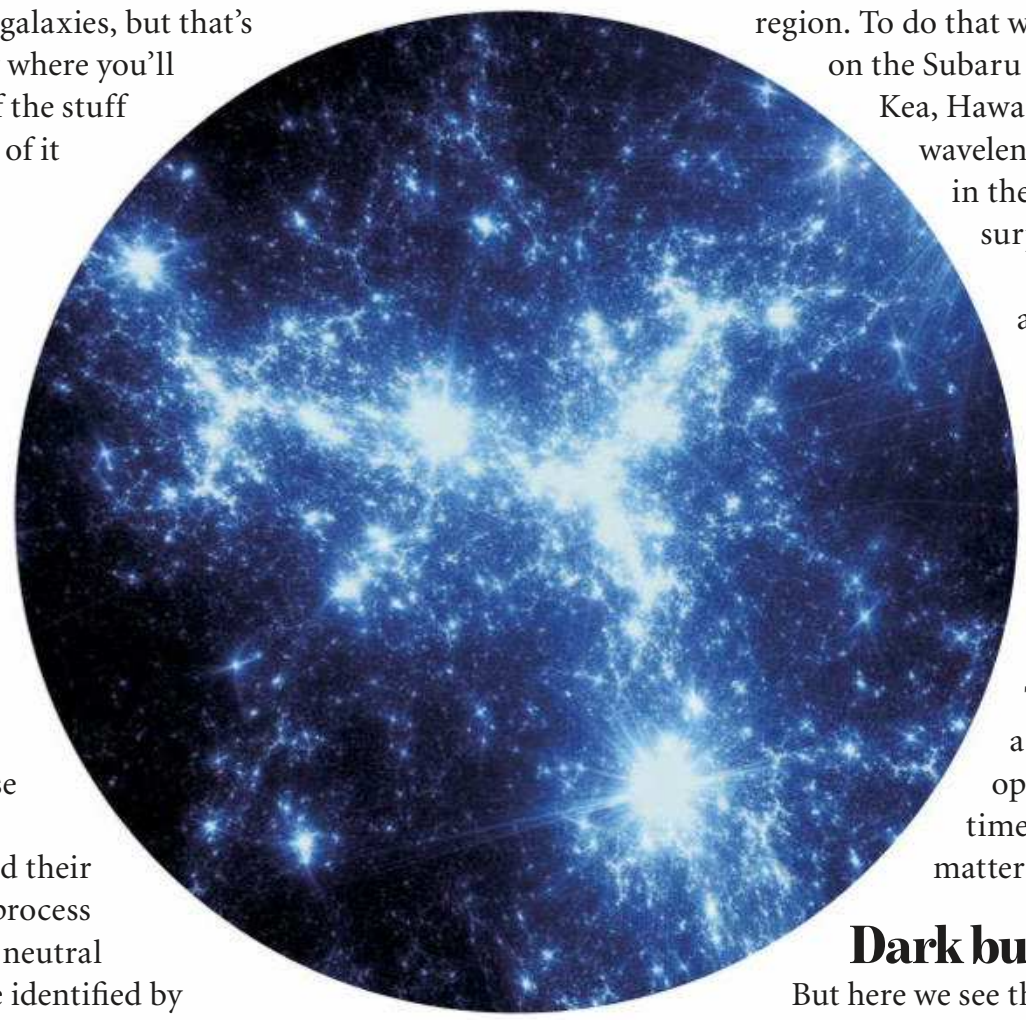
But if you go back far enough in time the Universe was completely opaque because it was filled with neutral, un-ionised gas. As stars formed their radiation ionised the gas in a process called reionisation. Patches of neutral hydrogen in deep space can be identified by being partly opaque to ultraviolet light since their atoms are very effective at absorbing it.

What my research has uncovered is a patch around a billion years after the Big Bang, when this transition from a mostly neutral Universe to a highly ionised Universe may have only just happened. We use quasars as background lights to study the gas in deep space. Towards one particular quasar there is a 500 million lightyear-long stretch where the ultraviolet light from the quasar was completely absorbed, suggesting that something was absorbing the light. Meanwhile, regions towards other quasars still show quite a lot of UV transmission. We wanted to know why there was such a large difference.

A surprising lack of galaxies

We thought that the region could either be low density with the little gas there is being predominantly neutral; or it could be a cold region in the Universe. If it is a region with little gas there should be few galaxies there because the two go together; but if it is a cold region, it should be full of gas and galaxies that have had plenty of time to cool after going through this ionisation process. So we started to look for galaxies in the region. To do that we used a powerful camera on the Subaru Telescope on Mauna Kea, Hawaii, using filters at multiple wavelengths let us count the galaxies in the opaque region. To our surprise we found very few.

If we'd done this experiment a little bit later in cosmic time, we would definitely have found a different result, because long after the galaxies form their ultraviolet light floods the Universe and ionises the hydrogen more or less equally everywhere. That means if you have a particular patch that is more opaque than others at these later times, it's because it has more matter in it blocking out the light.



Most of the 'stuff' in the Universe is stored in an intergalactic network of filaments that connects the galaxies

SAKKMESTERKE/ALAMY STOCK PHOTO

Dark but not dense

But here we see the opposite. It's the darkest place in the Universe at that time, but it's also one of the least dense. We may be seeing this patch at a time just after the galaxies appeared and ionised the gas. Before reionisation the gas and deep space would have been entirely neutral and therefore completely opaque to ultraviolet light.

We don't know exactly when this process of reionisation happened but we think that it was completed not long before the period we're talking about. The gas in this region may still have some neutral portion left. Alternatively, the ultraviolet radiation here may be weaker than it is elsewhere, perhaps because the radiation has a difficult time travelling even short distances in this particular patch of space.

The test of whether we're seeing reionisation ending or something that occurs long after ionisation will be when we look at the opposite type of region – one that has plenty of transmission.

We'd like to look at one of these very transparent regions. We have good spectra on them and I suspect that we will be going after more of these regions in the spring using the Subaru telescope.

ABOUT PROFESSOR GEORGE BECKER
George Becker is an assistant professor at the Physics and Astronomy Department of the University of California, Riverside

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THE SOUTHERN HEMISPHERE IN NOVEMBER

With Glenn Dawes

WHEN TO USE THIS CHART

1 NOV AT 24:00 AEDT (13.00 UT)
15 NOV AT 24:00 AEDT (13.00 UT)
30 NOV AT 23:00 AEDT (12.00 UT)

The chart accurately matches the sky on the dates and times shown for Sydney, Australia. The sky is different at other times as the stars crossing it set four minutes earlier each night.

NOVEMBER HIGHLIGHTS

Venus appears as a brilliant beacon low in the dawn sky in November after being in solar conjunction. A good time to start observing the planet is midmonth, around 45 minutes before sunrise. On 15 November it is an impressive 52-arcsecond diameter disc, appearing like a two-day-old Moon. From 11-20 November this 'goddess of love' is within 2° of the 1st magnitude star, Spica. By the end of December it has shrunk to only 26 arcseconds.

STARS AND CONSTELLATIONS

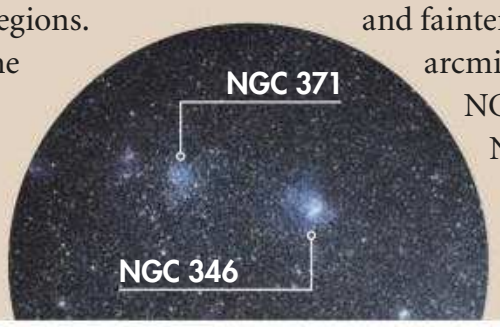
Obscure constellations Dorado, the Swordfish, and Tucana, the Tucan, are high in the southern sky. They look nothing like the creatures they're named after, nor have any obvious bright star patterns – a problem they share with Cancer. But all three boast notable naked-eye, nonstellar objects. Cancer has the Beehive Cluster, M44. The other two are homes to the Magellanic Clouds: the Large Magellanic Cloud (LMC) in Dorado and the Smalle Magellanic Cloud (SMC) in Tucana.

THE PLANETS

Jupiter is visible low in the twilight and lost in the solar glare by midmonth. Mercury's run of favourable evenings comes to an end, as it follows Jupiter into the deep twilight later in November. Saturn will soon follow, so catch it as early as possible. Mars and Neptune are still well placed in the northern sky, setting in the early morning. Uranus, having just passed opposition, is visible most of the night. Venus returns to the morning, being prominent low in the eastern dawn sky.

DEEP-SKY OBJECTS

The Magellanic Clouds are a very rewarding visual hunting ground. However, being significantly more distant than the Milky Way objects we observe, their star clusters are generally smaller and fainter. The SMC has a handful of impressive regions. Lying 2.7° due east of the magnificent globular cluster 47 Tucanae is NGC 346 (RA 0hr 59.1m, Dec. –72° 11'). Easily detectable through binoculars as a small hazy knot, it is revealed as a compact open star cluster when viewed through a telescope, embedded in a wispy oval nebula. 20 arcminutes east-northeast lies the open cluster NGC 371, larger, more diffuse and fainter than 346. Lying 20 arcminutes southwest of NGC 346 is the open cluster NGC 330. It is bright and compact, around one arcminute across, in a rich but faint star field.



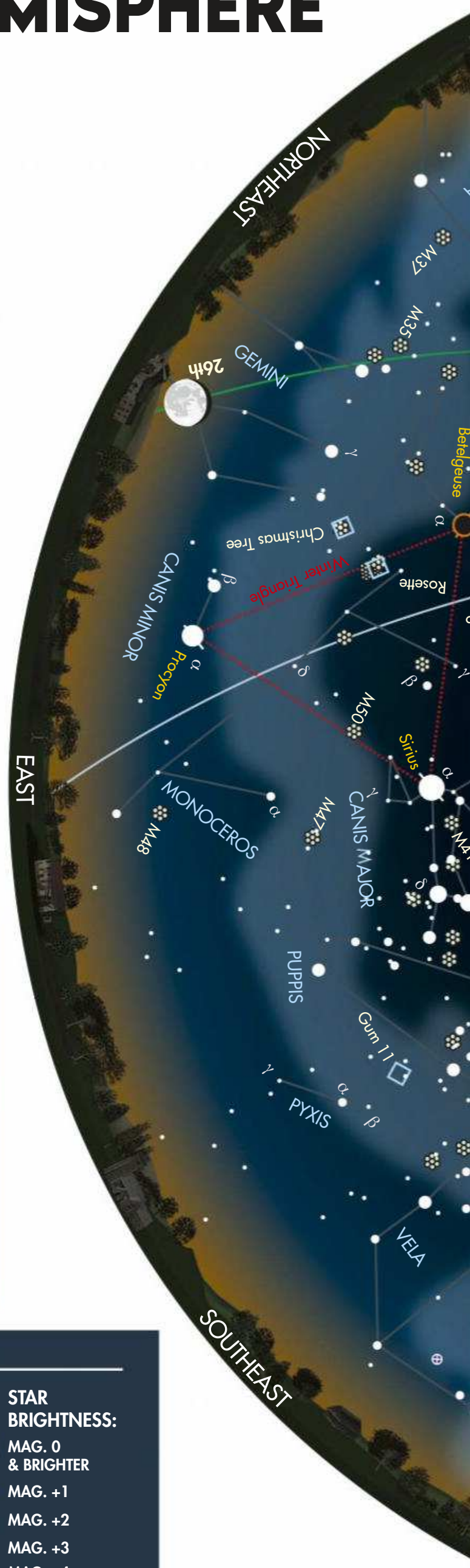
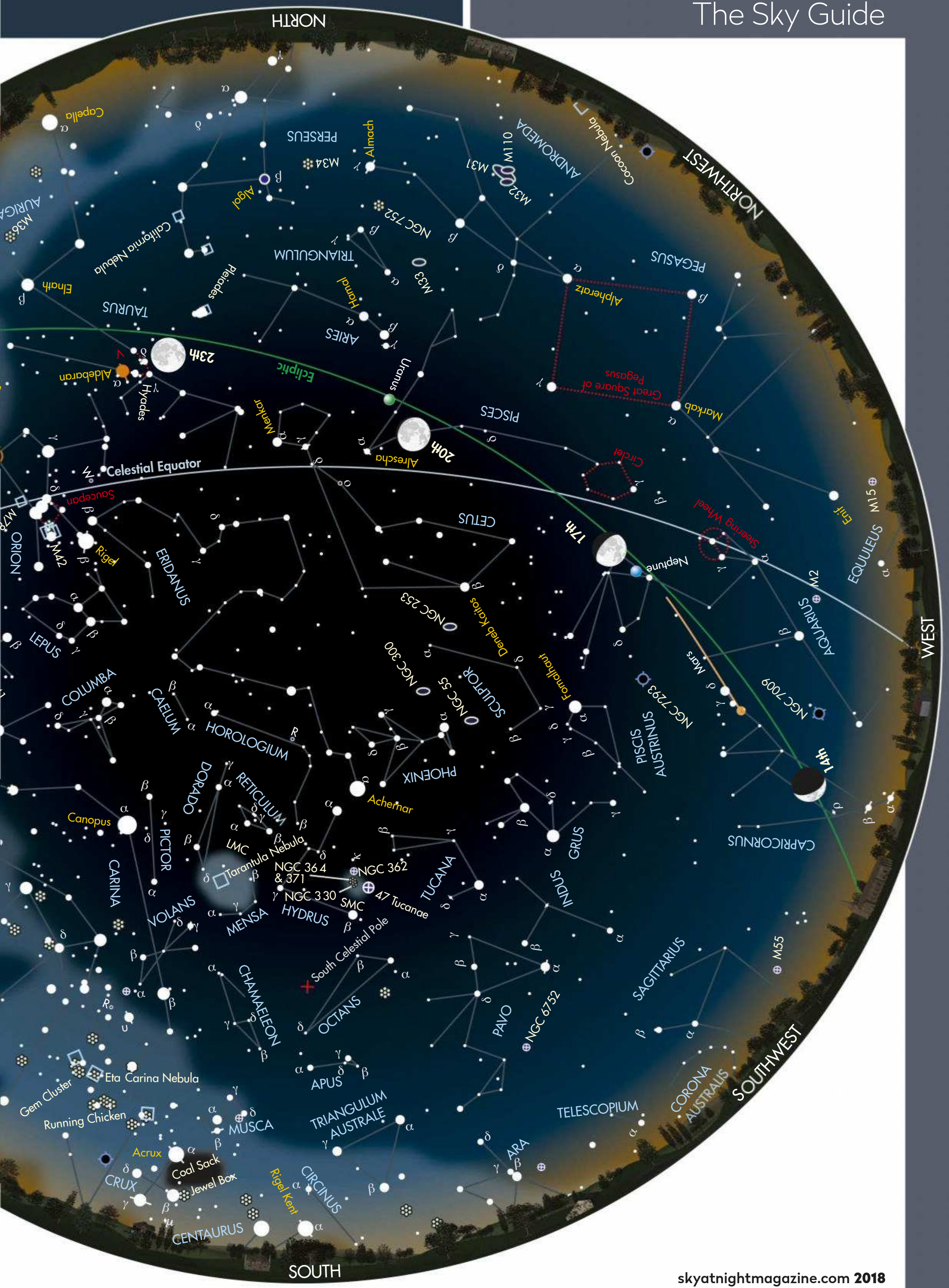


CHART KEY

- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- COMET TRACK
- ASTEROID TRACK
- METEOR RADIANT
- QUASAR
- PLANET

STAR BRIGHTNESS:
- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER

CHART: PETE LAWRENCE, IMAGE: KONSTANTIN VON POSCHINGER/CCDGUIDE.COM


NORTH
NORTHWEST
WEST
SOUTHWEST
SOUTH
Capella
PERSEUS
M34
Almach
Algol
M31
M32
M110
ANDROMEDA
Cocoon Nebula
AURIGA
M36
California Nebula
Elnath
Pleiades
TRIANGULUM
NGC 752
M33
Hamal
ARIES
TAURUS
PEGASUS
Alpheratz
23h
Ecliptic
Aldebaran
Hyades
Uranus
Great Square of Pegasus
Markab
Mercury
Celestial Equator
Menkar
PISCES
20h
Alrescha
Circlet
Saucepan
M78
ORION
M42
Rigel
ERIDANUS
CETUS
17h
Neptune
Steering Wheel
Enif
M15
EQUULEUS
M2
AQUARIUS
LEPUS
NGC 253
Deneb Kaitos
Fomalhaut
Mars
NGC 7293
NGC 7009
COLUMBA
CAELUM
HOROLOGIUM
NGC 300
SCULPTOR
NGC 55
PHOENIX
PISCIS AUSTRINUS
14h
DORADO
RETICULUM
Achernar
Canopus
PICTOR
CARINA
LMC
Tarantula Nebula
NGC 364
& 371
NGC 362
47 Tucanae
SMC
NGC 330
TUCANA
GRUS
CAPRICORNUS
VOLANS
MENSA
HYDRUS
South Celestial Pole
INDUS
CHAMAELEON
OCTANS
PAVO
NGC 6752
SAGITTARIUS
M55
Gem Cluster
Eta Carina Nebula
Running Chicken
MUSCA
TRIANGULUM AUSTRALE
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BBC Sky at Night MAGAZINE

Get into ASTROPHOTOGRAPHY

Go from your first steps in astrophotography to capturing lunar close-ups and beyond

There has never been a better time to get into astrophotography – the equipment you need to take great images continues to improve at an ever-increasing rate. Not that you need that much kit to get started. Consider your smartphone: its camera, more likely than not, is good enough to capture a decent photo of the brighter objects in the night sky, such as the Moon, clouds at the very edge of our atmosphere and aurorae. When used with a telescope or a pair of binoculars, you can get close-up shots of the same targets.

Yet with its low light levels and constant apparent movement, the night sky is one of the most demanding arenas in which to practise photography, one in which it really does pay off to invest in decent equipment such as a DSLR camera and a solid mount. Here we're going to look at these initial stages of your journey into astrophotography, as well as briefly what you need to capture more demanding targets such as planets, nebulae and galaxies.

WILL GATER

INSIDE

USING A SMARTPHONE

Your entry to astrophotography

The smartphones many of us carry in our pockets have cameras good enough to take photos of the night sky

▲ **A smartphone attached directly to a zoom lens**

The Moon shot with an iPhone using a specially-designed 12x mobile phone Photojojo zoom lens

It's surprisingly easy to achieve some good images of the brighter things in the night sky using just a smartphone, and when you use one with along with a telescope for afocal photography (see below), you can get some great close-up detail. Subjects suited to a smartphone on its own are daylight phenomena like sunrise and sunset; atmospheric effects like noctilucent clouds or solar halos; nightscapes with bright planets or the Moon; and wide-field images of constellations.

To get a good, clear photo it's essential to keep the smartphone still. This means mounting it on a tripod rather than holding it in your hand, using something like the Joby GripTight GorillaPod Stand (£25) or the XSories Pholder Smartphone Tripod Mount (£8.99), which sits on top of a tripod. A selfie stick tripod is also an option, such as Cygnett's GoStick Bluetooth Selfie Stick and Tripod (£30) or the BlitzWolf Selfie Stick Tripod (£15). You should also avoid touching the shutter button, so get a remote shutter release like the Thumbs Up Snap Remote (£14.99). Alternatively, you can use the shutter delay built into your phone's camera or, with an iPhone, you can plug in

Attaching your smartphone to a TELESCOPE OR BINOCULARS

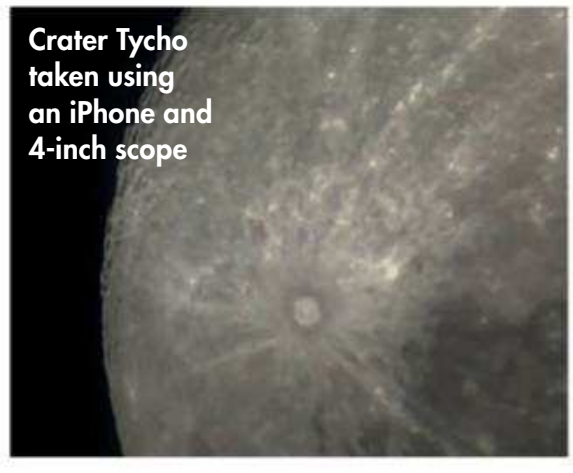
Using a technique called afocal photography means that even a humble mobile can get you closer to the detail

▲ **A smartphone/binocular combo**

When a camera lens is pointed through a telescope or some other form of lens to capture magnified images, this is a technique called afocal photography. Even using the camera on a phone with a telescope or binoculars you can get some good shots of the Moon or brighter planets, but it can be troublesome to keep the camera steady and aligned.

The easiest way is to simply position the phone's camera over the eyepiece of the telescope. It should be possible to get something on the screen of the phone by angling it in all directions around the edges of the eyepiece. If you don't see anything that could be because the object you're trying to image has moved out of view (if you have a high-power eyepiece in your telescope, that won't take long).

For more steadiness and reliable alignment get a smartphone holder. These are essentially a cradle for your phone that clips onto an eyepiece to enable more precise alignment. Examples include the Celestron NexYZ 3-Axis Smartphone Adapter (£50) and the Bresser Universal Smartphone Adapter (£35).



Crater Tycho taken using an iPhone and 4-inch scope

JAMIE CARTER X 7, PETE LAWRENCE X 2

Taking a TIME-LAPSE

Capture the dynamic movement of the night sky

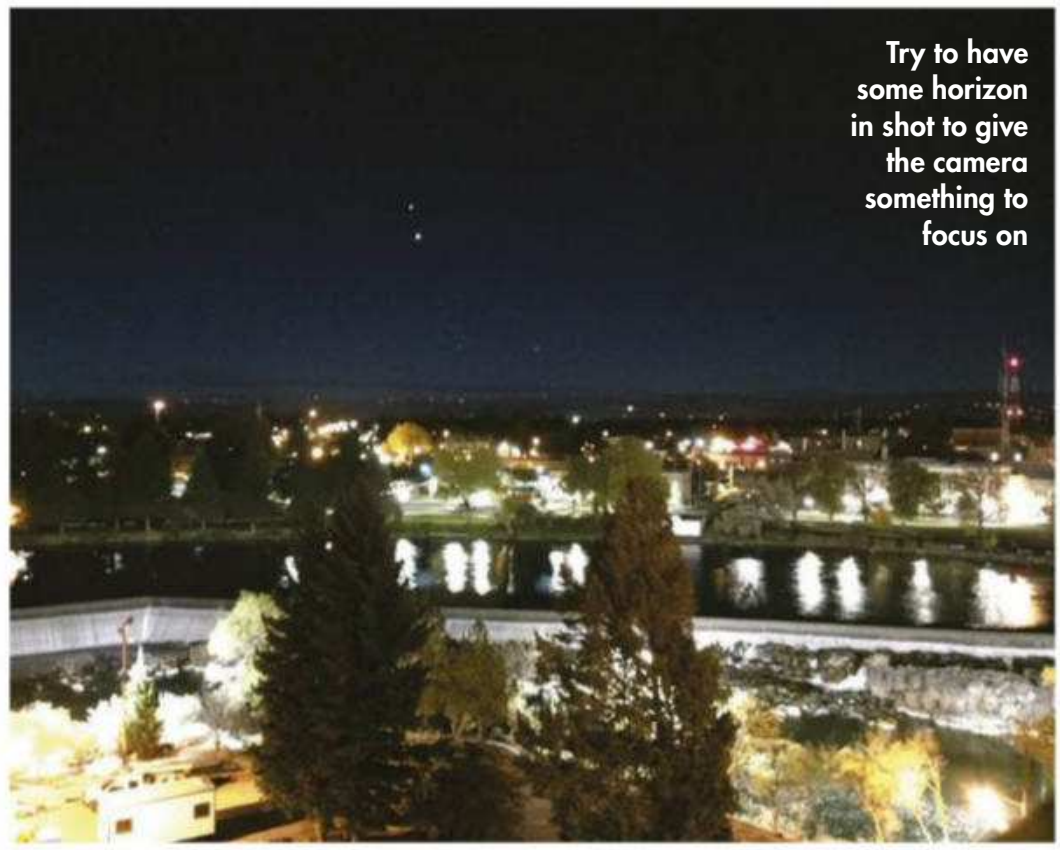
▲ **Film time-lapse movies using a tripod for steadiness**

By taking a series of photos at regular intervals over a period of 10 minutes or more you can make the Moon's motion across the sky, a sunrise or colourful clouds at sunset look really dramatic. It's easy with a smartphone. First, mount it securely and enable the remote shutter release. Make sure you have plenty of spare storage capacity on your phone – videos can be anywhere from 10MB to 500MB in size – then it's a case of focusing on the bright target.

Consider including a bright horizon in the frame to help you here, and since it's static it'll emphasise any movement in the sky beyond too. Before filming, be sure to focus on the Moon and put your camera app into AE (auto-exposure) lock mode to stop it compensating for changes in light. The iPhone and several Android phones have a time-lapse mode in their standard camera app. If your camera phone doesn't have one, consider apps like Lapse It (free; iOS and Android) or Timelapse Pro (free; Windows Phone).

▲ **No time-lapse mode on your phone? Then use Lapse It**

▲ **The iPhone has its own in-built time-lapse function**



Try to have some horizon in shot to give the camera something to focus on

your headphones and then use the volume control on their cord as a remote shutter release.

Start shooting

When you're ready to shoot, a wide-field shot of a bright object such as Mars, Jupiter or the Moon above the horizon is a great subject with which to start.

Even so, focusing on what appears to the camera as a bright dot can be challenging. That's where the horizon comes in: having it in the shot gives your smartphone something distant to focus on – more so if there are some lit regions on the ground. The camera's auto functions may pick up the night sky targets; if not, install an app that gives you manual control such as Night Cam! (iOS; £1.49) or Open Camera (Android; free).

Shooting constellations really pushes the limits of a smartphone's small-aperture camera – they can lack the brightness to register properly. With your phone securely mounted, you'll find focusing on constellations is even more of a challenge, so an app with manual camera control like NightCap Camera (iOS; £1.99) or Camera FV-5 (Android; £2.49) is even more crucial. You'll also need to increase the sensitivity of the camera: aim for as high an ISO as possible and use an exposure that's one second or more in length. Start with one of the brighter, more recognisable constellations – Orion in winter, Cygnus in summer, Leo in spring, Taurus in autumn – and if the resulting shots look dark at first, adjust the levels in a program like Photoshop or GIMP to reveal the brighter stars.

You can also take time-lapse photos to show the movement of the night sky, and point the camera down the eyepiece of a telescope for zoomed-in shots of the Moon or planets. But that's about the limit of the small-aperture, fixed focal length lens on a smartphone when it comes to capturing the night sky.

Orion is a winter constellation bright enough that it can be captured using a smartphone camera

How to take better photos with a DSLR

NIGHTSCAPES

You can use a DSLR camera on its own to achieve some great quality, stunning photos of the night sky

Smartphones are great for quick, grab-and-go shots of the night sky, but for larger, more detailed images use a camera with a larger aperture, a wider range of settings and manual control. With a digital single lens reflex (DSLR) camera or a MILC (Mirrorless Interchangeable Lens Camera) you can capture a much wider range of night-time subjects in better quality. They also have interchangeable lenses, so you can swap to a more powerful lens to close in on bright deep-sky objects.

Hands-on settings

The imaging chips in these cameras have wide ISO sensitivity ranges, allowing fainter light from more stars to be recorded for great results. You should also have an option to set the shutter speed – the exposure – in increments up to 30 seconds. After that, they'll have a bulb or 'B' setting that keeps the shutter open as long as the release is pressed to achieve even longer exposures – great for star trails.

DSLRs that suit budding astro imagers include the Canon EOS 1200D, 1300D, 750D and 200D models, and the Nikon D5600, D610 and entry-level D3400. Lenswise, the standard DSLR zoom lenses (18-55mm focal length) will capture the main constellations, brighter sections of the Milky Way and detail within aurorae. A wide-angle lens with a focal length of 16-28mm will take in the larger constellations and large auroral displays, and a telephoto lens of 100-500mm focal length will give zoomed-in views of bright stars in asterisms and clusters such as the Hyades.

Fixed focal length lenses are easier to focus than zoom lenses and they often have wider aperture settings,

A digital camera will help you to capture the finer details in aurorae

▼ Your essential starter kit: a tripod, camera and shutter release cable

A quick guide to CAMERA SETTINGS

A DSLR can capture many subjects. Here's how to get the best shots

Constellations
Exposure: 15 to 40 seconds
Aperture: f/2 to f/2.8
Sensitivity: ISO 800 to 1600

Twilight landscapes
Exposure: 1 to 10 seconds
Aperture: f/2.8 to f/5.6
Sensitivity: ISO 100

Aurorae
Exposure: 3 to 30 seconds
Aperture: f/2 to f/2.8
Sensitivity: ISO 400

Star trails
Exposure: 5 to 60 minutes
Aperture: f/4 to f/11
Sensitivity: ISO 100

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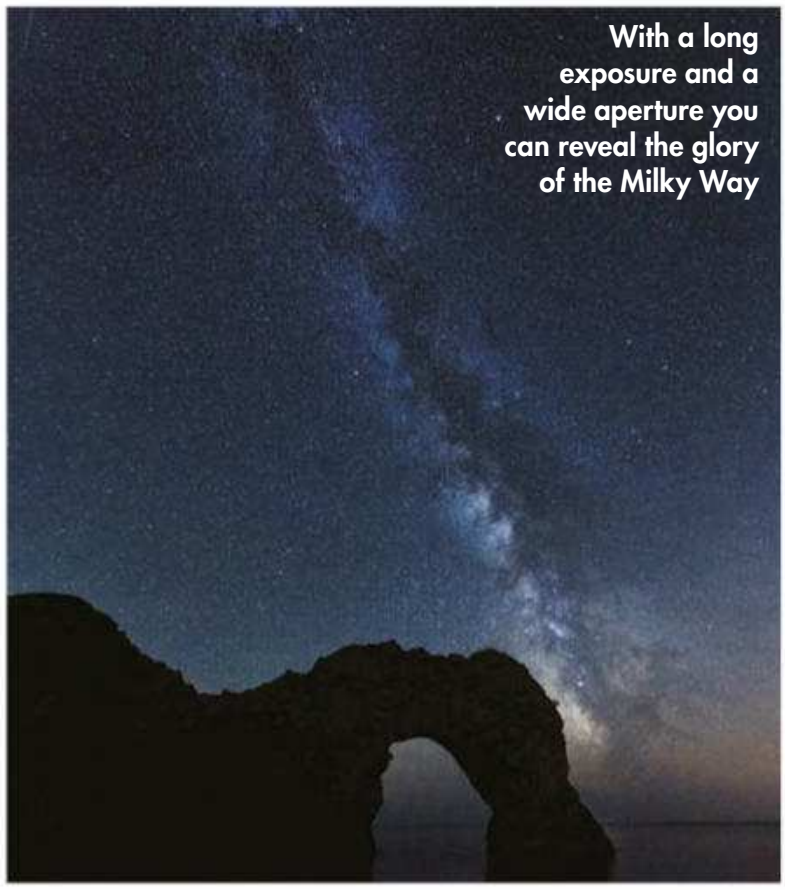


With a long exposure and a wide aperture you can reveal the glory of the Milky Way

It's perfectly possible to capture great constellation shots – this is Leo – from even a moderately dark site

Take a star trail image in FOUR EASY STEPS

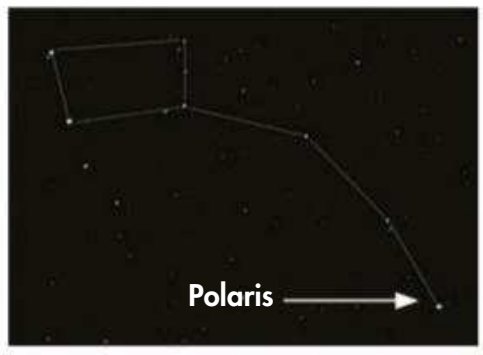
In the northern hemisphere the stars appear to rotate anticlockwise around one bright star: mag. +2.1 Polaris (Alpha (α) Ursae Minoris), also known as the Pole Star because it's almost exactly on the celestial pole. Over 24 hours the stars complete a circle around Polaris, so a 10-minute, wide-field exposure featuring the Pole Star will show Polaris as a dot and the stars farther from it with curving trails. Here's how to take a photo showing this dramatic effect.

Step 1

Use a wide-angle (16-28mm) or standard lens (35-70mm) for the best results for star trails and fix your camera to a tripod. Adjust the tripod legs so that they provide a solid base, and attach the remote shutter release so you don't vibrate the camera when taking the shot.

Step 2

Select an ISO of 400 and open the aperture as wide as it will go (the smallest f/number setting). Switch the camera to bulb mode so there's no limit to the length of the exposure, then focus. Make sure your flash is disabled and switch on the long-exposure noise reduction.



Step 3

Decide whether you want to shoot short star trails near Polaris, or longer trails by aiming at a constellation nearer to the celestial equator. Ursa Minor is a good choice for the former while Orion works well for the latter.

Step 4

Use the remote shutter release to take several exposures ranging in length from 5 to 30 minutes, then review them. If the sky is too bright in longer exposures, reduce the ISO to 100 or 200 and narrow the aperture to a larger f/number.

enabling more light to get to the sensor. Don't forget you'll also need a tripod and a remote shutter release to prevent unwanted camera movement.

To take good nightscape images with these cameras, don't use their in-built automatic exposure settings. These are useful when imaging in twilight, but when it's dark the auto routines don't cope well with low light levels. Switch to manual mode so that you can control the ISO, exposure and lens aperture settings.

Attach your camera to a tripod and plug in the remote shutter release cable. If you don't have one or you can't find the jack for it, use the delay timer. From a moderately dark site, you can get a good picture of a constellation like Leo with a 50mm focal length lens by setting the aperture as wide as it will go – f/1.8 or even f/1.4 – the ISO to 400 and the exposure to 15 seconds. Finding focus at night can also be tricky: zoom in on your camera's live-view screen if it has one, or focus on a bright object on the horizon. Remember to switch the autofocus to manual after you've achieved a sharp view.

Try bracketing your exposures: take a range of different exposure lengths at various ISO values to see which produces the image with the best overall balance between sky darkness and star brightness. Try exposing for five seconds either side of the initial exposure of 15 seconds.

How to take better photos with a DSLR
THE MOON

Capture high-quality images of the Moon with a DSLR camera and up-close detail using prime focus photography

The great thing about the Moon is that it's bright enough for you to take a decent image of it using a smartphone and a telescope – just hold your phone's camera lens up to the telescope's eyepiece and use the afocal method (see page 2).

You can, however, take the quality of your lunar images up another level if you use a DSLR or MILC camera. You'll capture more detail and less noise, while a longer focal length lens also allows you to increase the size of the Moon in your photos.

The great thing about these cameras is that they can also be fitted directly into your telescope's focuser – taking the place of the eyepiece – so that the telescope essentially becomes the camera lens. This allows you to employ a technique called 'prime focus photography', which can deliver shots that are much more close up.

To practise this technique you will need two accessories: a T-ring and a T-adaptor (the T refers to a specific type of thread, developed in 1957 by the Japanese optics company Taisei Kogaku, later known as Tamron). The T-ring is brand-specific and mounts on the DSLR. The T-adaptor screws into the T-ring and has a nosepiece to slot into the telescope's focuser.

Any scope can give great results with a DSLR, even a small 2.5-inch refractor or a 4-inch reflector. The longer your scope's focal length is, the closer up your images will be, though. This is why scopes like Schmidt- and Maksutov-Cassegrains are popular with top lunar photographers: they have long focal lengths, are well suited to close-up imaging of the Moon and, compared to a high-quality refractor, you get a much larger aperture for your money.

▲ First quarter Moon taken with a Nikon D200 through a Vixen VC200L scope

There is another way of getting close-up detail in images and that's

CHRISTOPH KALTSEIS/CCDGUIDE.COM, STEVE MARSH, WILL GATER, PETE LAWRENCE X 2, MICHAEL KARRER/CCDGUIDE.COM X 2,

Four top FIRST-TIME TARGETS

These lunar features make great targets for close-up lunar shots revealing lots of beautiful detail

Crater Clavius
This is a great target if you're trying to push your equipment to its limit. See how many of the small craterlets on the crater floor you can capture.

Montes Apenninus
This impressive chain of peaks, stretching around 600km, is one of the great lunar mountain ranges and a good target for afocal photography.

Crater Copernicus
One of the most stunning craters on the Moon, Copernicus makes for a wonderful imaging target. See if you can capture its magnificent terraced walls.

Vallis Alpes
This dramatic valley cuts across the lunar Alps. The challenge here is to see if you can capture the elusive rille that runs right through it.

▲ **You'll need a T-ring and a T-adaptor to connect your camera to your telescope**

by using a Barlow lens. Slot it in to a telescope's focuser before the DSLR camera and it'll increase the focal length of your system, giving you increased magnification images – typically by two or three times.

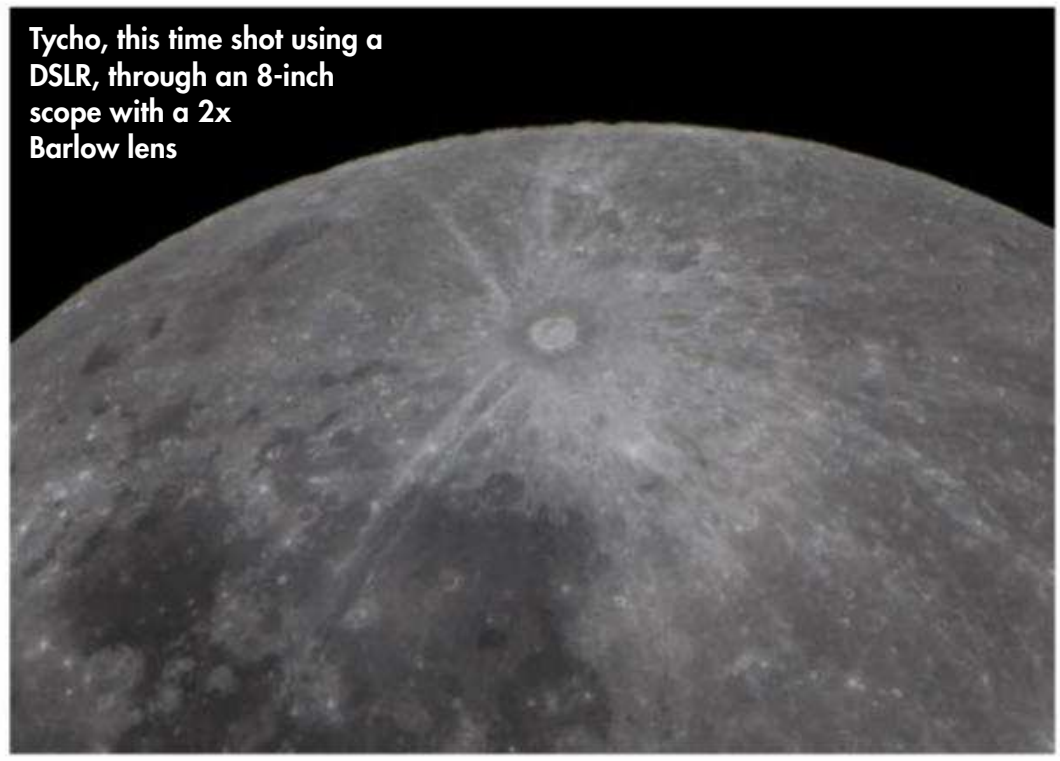
Your telescope's mount needs to be rock solid and stable, and the ability to track the Moon with a motor drive or a Go-To mount is a definite advantage. Don't forget to set your mount to track at the lunar rate, not at the rate the stars move across the sky. If you're using a Go-To mount, make sure that it's set up properly.

Moon shots

Once set up, the first step to capturing lunar close-ups is to work out the best time to capture your target (see the box on the right for apps to help you to do this). To reveal the intricate, rugged surface of the Moon's crust it's best to take your shots with your target lit from an extreme angle, which happens when the terminator (the line between the light and dark areas of the Moon) is close by. A very turbulent atmosphere, known to astronomers as bad 'seeing', can also blur and distort your view of the Moon – like the heat haze rising from a road on a warm day. You can tell when the seeing's good as the stars won't be twinkling much. That's when you'll capture the best lunar images.

You can't control these seeing conditions high up, but you can cut down on air turbulence lower to the ground. Leave your scope to cool down outside for about an hour before you start imaging and this will reduce wobbling in your images as there's less heat rising from your instrument. For similar reasons don't take images from indoors looking out of a window or doorway. Heat from the house will cause the view to shimmer wildly.

Try an ISO setting of 200 to 400 at first, though you may want to progressively increase the sensitivity. Bracketing you shots (see page 5) works particularly well with lunar imaging. It's a good way to deal with the often big differences in brightness with lunar features, so take multiple images with a wide range of exposures and ISOs. Taking lots of frames will also help you capture those moments of best seeing when the atmosphere is still. There's an even better way of dealing with the unwanted effects of poor seeing, which you may want to move onto as your astro imaging skills progress. Turn the page to discover more.


Tycho, this time shot using a DSLR, through an 8-inch scope with a 2x Barlow lens

PLANNING TOOLS

The best free apps and software for lunar imaging

Moon Globe

This great free app can be used on your iPhone, iPod touch or iPad. It shows what the Moon looks like for a given date and time, complete with accurate shadow details.

Via iTunes App Store

Stellarium

This free planetarium software lets you know where the Moon will be at any time – handy if you're planning a night-long lunar imaging session.

stellarium.org

Virtual Moon Atlas

An authoritative piece of freeware for planning your observations in detail, it features an interactive atlas and a feature-rich info panel.

ap-i.net/avl/en/start

NEXT STEPS
in astrophotography

Some of the advanced equipment and techniques used by experienced astro imagers to capture stunning images

▲ A single frame taken by an HFR camera will look like the image on the left, but many such images can be combined, or 'stacked', to produce the final image (right)

The Moon and planets

While imaging the Moon using a DSLR camera at a scope's prime focus gives good images, slotting a high frame-rate (HFR) camera in at prime focus on a similar setup will deliver the best results. The files cameras like ZWO's ASI120MC-S (£151) or the Celestron NexImage Burst Imager (£200) capture aren't the finished picture, though: they need to be processed with specialist software.

That's because HFR cameras take video rather than still images, which typically consists of hundreds of individual frames a second. This helps overcome issues with bad seeing. An HFR camera's five-second video with, say, 600 separate frames will record many more moments when the target's seen through a still atmosphere than the one exposure a DSLR camera takes in the same time.

Specialist software like RegiStax or AutoStakkert! is needed to separate the video into individual frames, and then electronically combine these frames in a process called 'stacking'. It's with HFR cameras and stacking that experienced imagers take their best photos of the planets too.

The Sun

Our star is so bright it poses a real danger to eyesight and equipment, so care must be taken to keep the ends of any telescope pointed at the Sun covered with either end caps or a specialist solar filter.

There are different types of filter that cut out most of the energy of the Sun's light. White light filters (under £100) allow a tiny portion the Sun's spectrum through and show detail on the Sun's visible surface. Hydrogen-alpha and Calcium-K filters only show light from those respective parts of the Sun's full spectrum, but these are expensive (around £2,000). They do, however, enable solar imagers to use large aperture telescopes to capture stunning detail at different levels on the Sun's chromosphere.

Typically a filtered telescope sits on a driven mount that tracks the sky at the same rate it would the stars. As for cameras, the same advice applies: a DSLR camera at prime focus is good but an HFR camera is better.

▲ The Atik Horizon is an example of what's known as a cooled camera – a fan keeps the sensor from overheating during long exposures

▲ You can view the Sun with a range of kit, from specialist solar telescopes to filtered instruments

Galaxies and nebulae

The challenge with galaxies is they are so faint that capturing enough of their photons to produce decent images requires long exposures and incredibly accurate tracking.

So a sturdy, well-aligned mount and tripod are key. EQ5- or EQ6-type mounts (£550 and £1,250 respectively) are popular choices. Though Go-To isn't necessary, a motorised RA axis that tracks the sky during long exposures is a must. Expert imagers often keep their setup on track by 'autoguiding' it; correcting any drift with a separate scope, camera and tracking software.

DSLR cameras work well on galaxies, though their sensors can become hot during long exposures, increasing unsightly noise. To combat this, specialist CCD or CMOS cameras like the ZWO ASI071MC Pro Cooled (£1,600) or the Atik Horizon (£1,260) have built-in fans to cool their sensors. Processing is important here too: typically many calibration frames are combined with the final image to remove noise and hot pixels using software such as DeepSkyStacker.

This is just an introduction to capturing the more demanding yet rewarding targets that await in the night sky. You can find more detailed imaging advice in each monthly issue of the magazine.

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